Oracle Spatial for PostGIS Users – Understand, Isolate and Migrate

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Introduction

- Oracle Spatial and PostGIS are two of the most mature implementations of a spatial type system for their relevant host databases.
- PostgreSQL/PostGIS is increasing in strength, EnterpriseDB is aiming to convert businesses from Oracle to PostgreSQL but....
  - You rarely see, on a customer's servers, only ONE DB product;
  - Learn to live together: Not Either/Or but Both/And!
- This talk provides an understanding of:
  - Oracle Locator/Spatial concepts and components;
  - Relevant standards in common;
    - Metadata structures;
    - Type system.
  - Tolerance model
  - Programmatic and framework issues.
  - Helping you understand each, and know how to migrate between or minimise solutions that can be deployed on both databases.

Oracle Releases

- Oracle's first version of “Spatial” was released with 8iR1 (8.1.5) back in 1999 (10 years ago).
  - OpenGIS SFS for SQL was released in 1999;
  - No initial support for OGC/SQLMM object type:
    - “Singly inherited”?
    - Timing of releases?
  - Had 6 major releases since some with, without major spatial releases:
    - 9i Releases 1 (9iR1) and 2 (9iR2)
    - 10g Releases 1 (10gR1) and 2 (10gR2)
    - 11g Releases 1 (11gR1) and 2 (11gR2)

Oracle Spatial Functionality Releases…

8i	Basic SDO_Geometry type & Quad Tree indexing
9iR1	Geodetic, Linear Referencing System, RTree Spatial index, Spatial Aggregate functions, Partitioned Indexes
9iR2	Various function additions and changes eg SDO_AGGR_UNION, SDO_AGGR_MBR
10gR1	Annotation Point GeoRaster, Network Data Model, Geocoding, Topology, Spatial Analysis and Mining (Spatial correlation , colocation, clustering, prospecting, binning) Various function additions and changes.
10gR2	EPSG SRS, WKB in/out, Various function additions and changes.
11gR1	TIN SOLIDS POINTCLOUDS, 3D RTree indexing and some 3D query operators.
11gR2	SDO_AGGR_SET_UNION (cf STRM ST_Union) Various function additions and changes. KML in/out; GML in

Oranges and Lemons

- Oracle's “spatial” functionality is available in two versions: Locator and Spatial.
  - **Locator** is a free feature of Oracle Database available on all versions (XE, SE1, SE, and EE) and releases from 9iR1 that implements the basics of a vector type system that includes:
    - An object type (SDO_GEOMETRY) that describes and supports any type of geometry (whole earth geometry model for geodetic data introduced in 9iR1 – **PostGIS end of 2009**);
    - A spatial indexing capability (Quad Tree and RTree);
    - Spatial index aware operators for performing spatial queries;
    - Some geometry functions (not geoprocessing eg SDO_Union) and the SDO_AGGR_MBR spatial aggregate function;
    - Coordinate system support for explicit geometry transformations;
    - Spatial utility functions (eg Rectify_Geometry cf SQL Server 2008's MakeValid)

Oranges and Lemons (Cont)

- **Spatial** includes:
  - All Spatial Functions e.g. SDO_Union and aggregates e.g. SDO_AGGR_UNION;
  - Linear Referencing System ***(c.f. PostGIS LRS functions)***;
  - GeoRaster Storage, Indexing and Querying *(cf WKT Raster beta)*;
  - Network Data Model;
  - Topology Data Model ***(c.f. PostGIS Topology beta implementation)***;
  - Spatial Analysis and Mining (SAM) Functions;
  - Spatial Routing Engine ***(c.f. PostGIS pgRouting)***;
  - Geocoding Engine;
  - 3-D Geometry, Surface, and Point Cloud Storage; Index and Query;
  - Semantic Content Storage, Indexing and Querying (RDF/OWL Support).
- Cannot be purchased separately!
- Can only be deployed on Enterprise Edition (EE)!

Parallel Processing, Partitioning and Replication

- Oracle’s native spatial data type allows for:
  - Partitioning support for spatial indexes;
  - Parallel index builds for spatial R-tree indexes;
  - Parallel spatial queries;
  - Replication
- Some features available only with Enterprise Edition.
  - And so, $$$$$$$$$$$$$$$$$$$$$

Software that supports Oracle

- Oracle's focus, as always, is on sales and marketing.
- Technology Partners and Spatial Integrator Partners are all commercial businesses.
- But FOSS4G software also supports Oracle:
  - OGR, GDAL, FDO, uDig, GeoTools, Quantum GIS, GeoServer, Deegree, MapServer, MapGuide OS....

Autodesk
INTERGRAPH
PCI Geomatics
Leica Geosystems
Geodan
ESRI
Skyline DELIVERING THE DIGITAL EARTH
GE
e|spatial spatially enabling business
NAVTEQ
MapInfo.
BENTLEY
AED SICAD AKTIENGESELLSCHAFT
cadcorp
exor
caris
ionic SOFTWARE
ACQUIS
STAR-APIC
POWEL | miniMax
SAFE SOFTWARE
ObjectFX
Laser-Scan
Tele Atlas

Standards Bodies …

- We look to those standards bodies that are defining applicable standards to control/support design, use and uptake of spatial databases:
  - Open Geospatial Consortium (OGC) Inc
  - International Standards Organisation (ISO)
  - W3C Consortium (XML/SVG…)
- Help to “level the playing fields” for open source projects.
- Oracle participates actively on technical committees eg authoring/editing of SQL/MM standards by Dr John Herring.

Applicable Spatial Standards…

- OpenGIS Standards (Latest)

OpenGIS Document Title	Version	Type
OpenGIS Implementation Specification for Geographic Information - Simple Feature Access (ISO 19125) *Part 1: Common Architecture* Supplies the common feature model for use by applications that will use the Simple Features data stores and access interfaces. *Part 2: SQL option* Provides a standard SQL implementation of the abstract model in Part 1 that supports storage, retrieval, query and update of features. Includes Normalised, Binary and "SQL with Geometry Types"1 (Says nothing about physical storage format) implementation options	1.2	IS

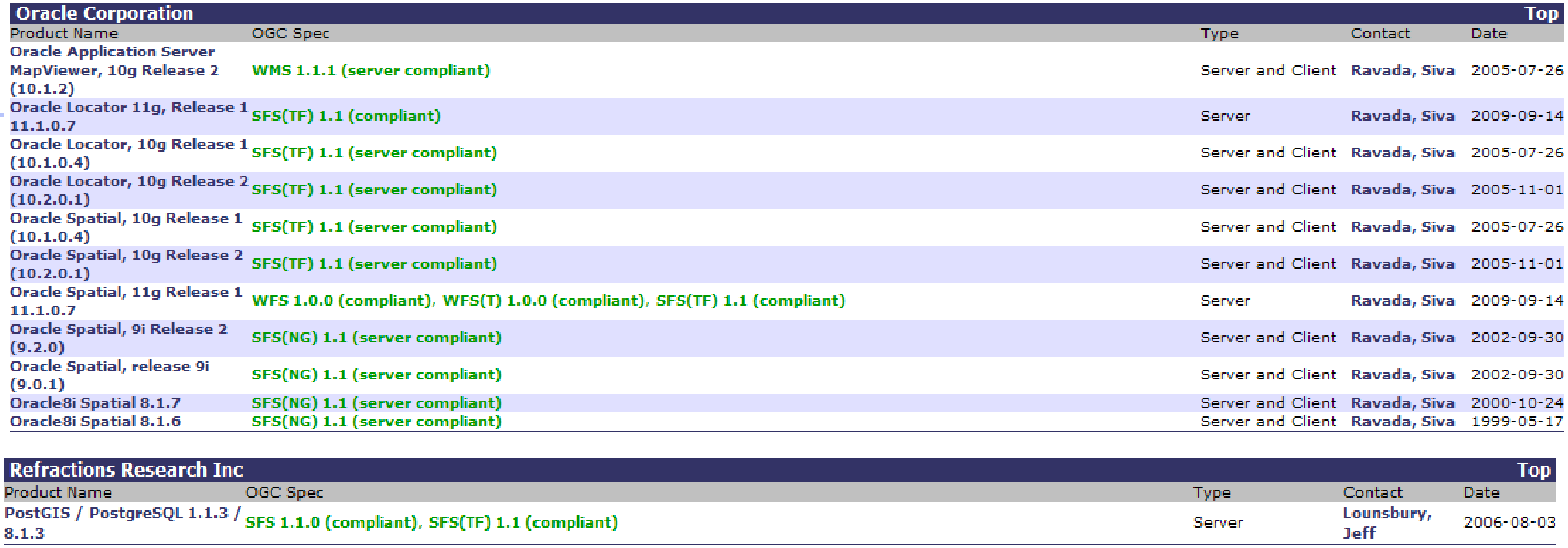
IS - Implementation Specification
DIS - **Deprecated** Implementation Specification
SAP - Specification Application Profile

- ISO Standards (Latest)

ISO Document Title
ISO/IEC CD 13249-3:2006(E) – Information technology – Database languages – SQL Multimedia and Application Packages — Part 3: Spatial, May 15, 2006.
ISO 19107, Geographic information ◎ Spatial schema
ISO 19111, Geographic information ◎ Spatial referencing by coordinates (Implemented in the EPSG collection of geodetic systems)

OGC Standards Compliance

- Both original SDO_* and ST_* implementations have been submitted to standards bodies.



Oracle Corporation				Top
Product Name	OGC Spec	Type	Contact	Date
Oracle Application Server MapViewer, 10g Release 2 (10.1.2)	WMS 1.1.1 (server compliant)	Server and Client	Ravada, Siva	2005-07-26
Oracle Locator 11g, Release 1 11.1.0.7	SFS(TF) 1.1 (compliant)	Server	Ravada, Siva	2009-09-14
Oracle Locator, 10g Release 1 (10.1.0.4)	SFS(TF) 1.1 (server compliant)	Server and Client	Ravada, Siva	2005-07-26
Oracle Locator, 10g Release 2 (10.2.0.1)	SFS(TF) 1.1 (server compliant)	Server and Client	Ravada, Siva	2005-11-01
Oracle Spatial, 10g Release 1 (10.1.0.4)	SFS(TF) 1.1 (server compliant)	Server and Client	Ravada, Siva	2005-07-26
Oracle Spatial, 10g Release 2 (10.2.0.1)	SFS(TF) 1.1 (server compliant)	Server and Client	Ravada, Siva	2005-11-01
Oracle Spatial, 11g Release 1 11.1.0.7	WFS 1.0.0 (compliant), WFS(T) 1.0.0 (compliant), SFS(TF) 1.1 (compliant)	Server	Ravada, Siva	2009-09-14
Oracle Spatial, 9i Release 2 (9.2.0)	SFS(NG) 1.1 (server compliant)	Server and Client	Ravada, Siva	2002-09-30
Oracle Spatial, release 9i (9.0.1)	SFS(NG) 1.1 (server compliant)	Server and Client	Ravada, Siva	2002-09-30
Oracle8i Spatial 8.1.7	SFS(NG) 1.1 (server compliant)	Server and Client	Ravada, Siva	2000-10-24
Oracle8i Spatial 8.1.6	SFS(NG) 1.1 (server compliant)	Server and Client	Ravada, Siva	1999-05-17

Refractions Research Inc				Top
Product Name	OGC Spec	Type	Contact	Date
PostGIS / PostgreSQL 1.1.3 / 8.1.3	SFS 1.1.0 (compliant), SFS(TF) 1.1 (compliant)	Server	Lounsbury, Jeff	2006-08-03

Prefixes and Naming …

- “ST/ST_” Prefix….
  - Seems to be universally accepted in PostGIS, QSL Server 2008, Oracle SQL/MM type, Informix…
  - OGC SFS 1.2 does not mention it.
  - ISO/TC 211 N 2393 (19125-2), “7.2.2.2 Language constructs” says:

    “Note: Class names in SQL/MM carry a "ST_" prefix. This is optional and implementations may chose to drop this prefix as has been done in various places in this standard.”
  - *ISO/IEC 13249 “3.2.2 Notations provided in Part 3” says:*

    “This part of ISO/IEC 13249 uses the prefix 'ST_' for user-defined type, attribute and SQL-invoked routine names.”

Prefixes and Naming - Search

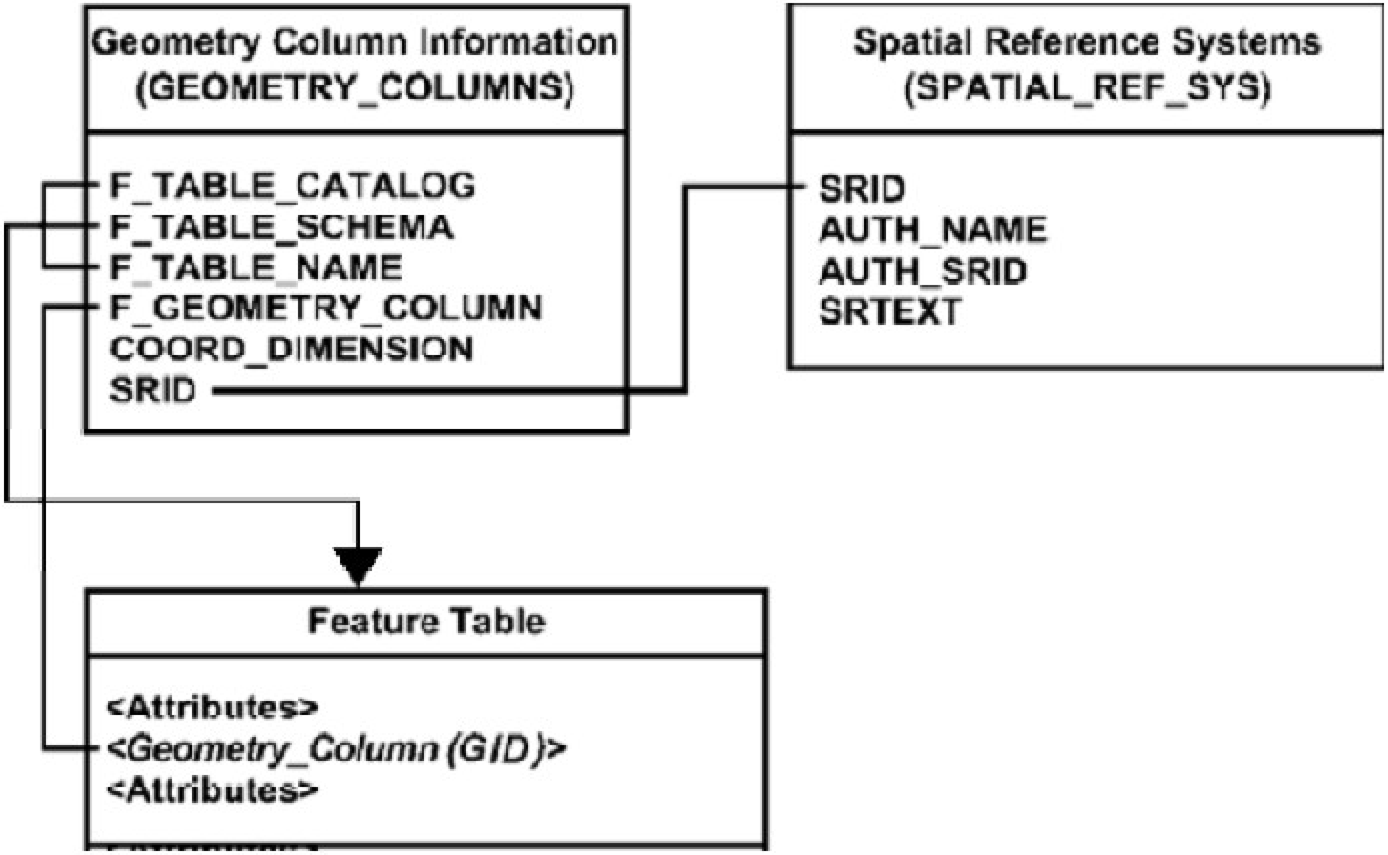
- Oracle's standard search operators that use spatial indexes are of the following form:
  - SDO_<predicate> eg
    - SDO_ANYINTERACT (ie ST_Intersects)
    - SDO_CONTAINS
    - SDO_COVEREDBY
    - SDO_COVERS
    - SDO_EQUAL
    - SDO_FILTER (Primary Filter)
    - SDO_INSIDE
    - SDO_NN
    - SDO_ON
    - SDO_OVERLAPBDYDISJOINT
    - SDO_OVERLAPBDYINTERSECT
    - SDO_OVERLAPS
    - SDO_RELATE (generic wrapper not 9matrix)
    - SDO_TOUCH

Metadata.....

Schema for Geometry Types

ISO/TC 211 6.2 Architecture — SQL implementation using Geometry Types, 6.2.1 Overview:

"This standard defines a schema for the management of feature table, Geometry, and Spatial Reference System information in an SQL-implementation with a Geometry Type extension."



Geometry Columns – The Standard

- Eg OCG (1.2):

```
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,
  G_TABLE_CATALOG   CHARACTER VARYING NOT NULL,
  G_TABLE_SCHEMA    CHARACTER VARYING NOT NULL,
  G_TABLE_NAME      CHARACTER VARYING NOT NULL,
  STORAGE_TYPE      INTEGER,
  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)
)
```

- For the GEOMETRY_TYPE column, the "use of a non-leaf Geometry class name from the Geometry Object Model for a geometry column implies that domain of the column corresponds to instances of the class and all of its subclasses" **[OGC 06-104r3, 7.1.3.3 Field description, Page 29]**

Geometry_Columns - PostGIS

-
  ```
  CREATE TABLE geometry_columns
  (
    f_table_catalog   character varying(256) NOT NULL,
    f_table_schema    character varying(256) NOT NULL,
    f_table_name      character varying(256) NOT NULL,
    f_geometry_columncharacter varying(256) NOT NULL,
    coord_dimension   integer NOT NULL,
    srid              integer NOT NULL,
    "type"            character varying(30) NOT NULL,
    CONSTRAINT geometry_columns_pk PRIMARY KEY
      (f_table_catalog, f_table_schema,
       f_table_name,    f_geometry_column)
  );
  ```
- Notes:
  - Doesn't bother with G_* columns
  - Geometry Type column is named “type” and is a character field not integer.
  - PostGIS's Management Functions for this table eg AddGeometryColumns does not insert “super-type” into “type” when mixed geometry types appear in table as per standard. So, MultiPolygon does not include “Polygon” as it is required to do.

Geometry_Columns - Oracle

-
  ```
  CREATE TABLE MDSYS.OGIS_GEOMETRY_COLUMNS (
    F_TABLE_SCHEMA    VARCHAR2(64),
    F_TABLE_NAME      VARCHAR2(64),
    F_GEOMETRY_COLUMN VARCHAR2(64),
    G_TABLE_SCHEMA    VARCHAR2(64),
    G_TABLE_NAME      VARCHAR2(64),
    STORAGE_TYPE      NUMBER,
    GEOMETRY_TYPE     NUMBER,
    COORD_DIMENSION   NUMBER,
    MAX_PPR           NUMBER,
    SRID              NUMBER,
    CONSTRAINT FK_SRID FOREIGN KEY (SRID) REFERENCES
      MDSYS.OGIS_SPATIAL_REFERENCE_SYSTEMS (SRID)
  )
  ```
- There is no global GEOMETRY_COLUMNS view only Oracle-specific USER_GEOMETRY_COLUMNS and ALL_GEOMETRY_COLUMNS public views based on MDSYS.OGC_GEOMETRY_COLUMNS table.
- The MAX_PPR and G_TABLE_SCHEMA/G_TABLE_NAME columns are no longer of any use as Oracle's implementation of the Normalised model has long been dropped.
  - Note: Oracle does not have concept of a CATALOG so F_TABLE_CATALOG was never supported.
- STORAGE_TYPE should always be NULL = geometry types implementation (OGC SFS SQL 1.2)
- Geometry_Type column is declared as a Number/Integer

PostGIS Management Functions….

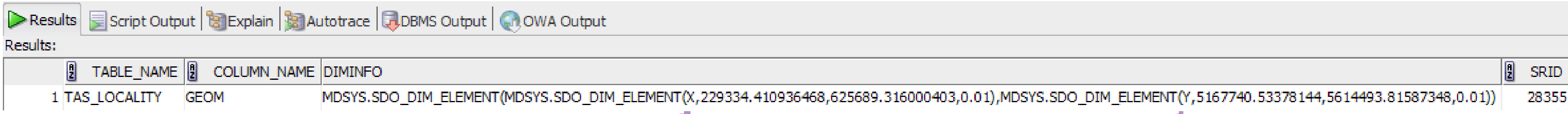
- In Oracle there are no equivalent Management Functions for metadata management to these in PostGIS (not that these are hard to write):
  - **AddGeometryColumn**
    - Adds a geometry column to an existing table.
  - **DropGeometryColumn**
    - Removes a geometry column from a spatial table.
  - **DropGeometryTable**
    - Drops a table and GEOMETRY_COLUMNS reference.
  - **Populate_Geometry_Columns**
    - Ensures geometry column metadata exists in GEOMETRY_COLUMNS and table has appropriate spatial constraints (not requirement of standard).
  - **Probe_Geometry_Columns**
    - Scans all tables with PostGIS geometry constraints and adds them to the GEOMETRY_COLUMNS table if they are not there.
  - **UpdateGeometrySRID**
    - Updates the SRID of all features in a geometry column, GEOMETRY_COLUMNS metadata and srid table constraint

xxx_SDO_GEOM_METADATA

- No Oracle functions know of, or use, MDSYS.OGC_GEOMETRY_COLUMNS
- Rather, all use Oracle-specific metadata tables, the most basic being:
-
  ```
  CREATE TABLE mdsys.sdo_geom_metadata_table (
     owner        varchar2(32),
     table_name   varchar2(32),
     column_name  varchar2(32),
     diminfo      mdsys.sdo_dim_array,
     srid         number );
  ```
  - Needed mainly for creation of indexes.
  - Populated by user or client software.
-
  ```
  CREATE TYPE sdo_dim_array AS VARRAY(4) OF
  mdsys.sdo_dim_element;
  ```
  - Has an sdo_dim_element for each dimension ie X, Y, Z or M
-
  ```
  CREATE TYPE sdo_dim_element AS OBJECT (
    sdo_dimname   varchar2(32),
    sdo_lb        number,
    sdo_ub        number,
    sdo_tolerance number );
  ```
  - Holds range of all data in table/column for that dimension.
  - Some GIS software use diminfo as an accurate extent of all data in table.
  - Also, precision (see later) of the data in those ranges.

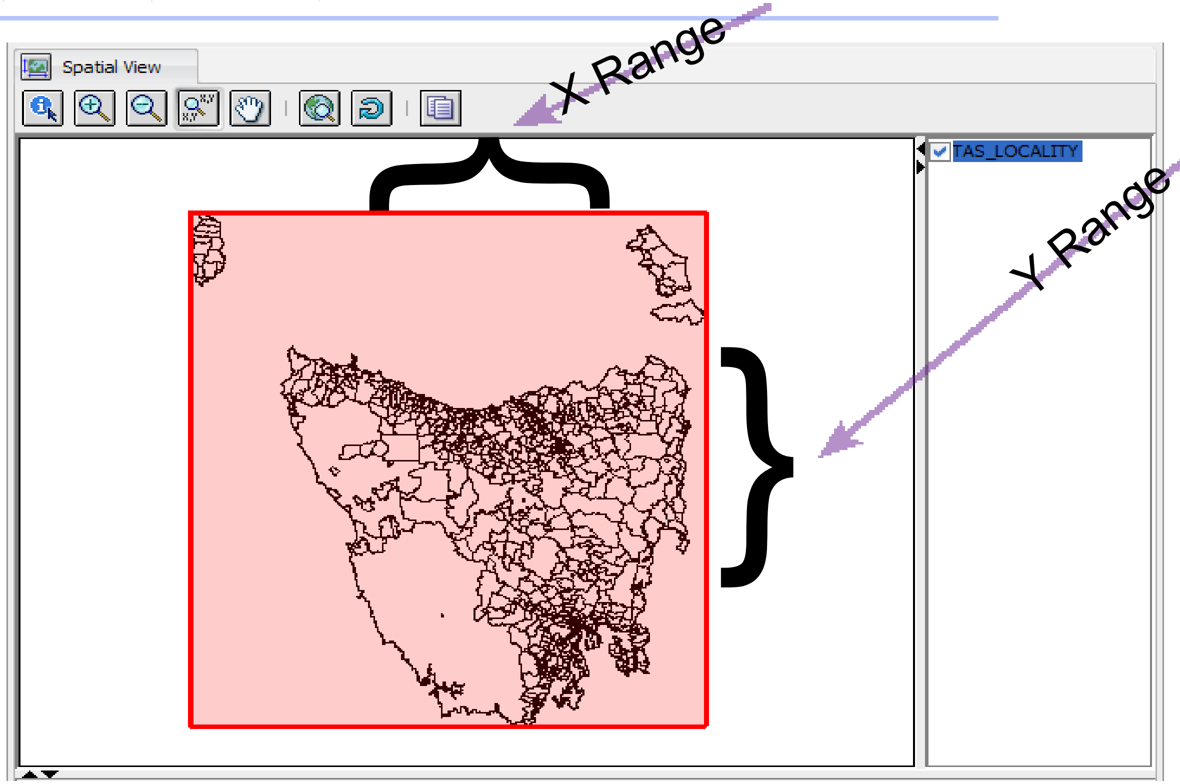
SDO_DIM_ARRAY - Example

```
SELECT *
  FROM user_sdo_geom_metadata
 WHERE table_name = 'TAS_LOCALITY';
```



Results:

	TABLE_NAME	COLUMN_NAME	DIMINFO	SRID
1	TAS_LOCALITY	GEOM	MDSYS.SDO_DIM_ELEMENT(MDSYS.SDO_DIM_ELEMENT(X,229334.410936468,625689.316000403,0.01),MDSYS.SDO_DIM_ELEMENT(Y,5167740.53378144,5614493.81587348,0.01))	28355



Geometry Columns (3)

- Oracle does not automatically synchronise GEOMETRY_COLUMNS as DML is executed against ****_SDO_GEOM_METADATA views.
- Manual DML executed against actual OGC_GEOMETRY_COLUMNS table or views generates errors.
- One approach is to build public viewcalled GEOMETRY_COLUMNS over existing metadata (value-added within functions) as follows:

  -
    ```
    CREATE VIEW GEOMETRY_COLUMNS
    AS
    SELECT asgm.owner             as F_TABLE_SCHEMA,
           asgm.table_name        as F_TABLE_NAME,
           asgm.column_name       as F_GEOMETRY_COLUMN,
           NULL                   as STORAGE_TYPE,
           Get_Geometry_Type(asgm.owner,
                             asgm.table_name,
                             asgm.column_name)
                             as GEOMETRY_TYPE,
           (SELECT count(*)
              FROM TABLE(asgm.diminfo)
           )                 as COORD_DIMENSION,
           asgm.SRID              as SRID
      FROM ALL_SDO_GEOM_METADATA asgm;
    ```

    (Note: I have implemented the function Get_Geometry_Type() that returns the correct OGC Geometry_Type - see my website for details.)

  -
    ```
    CREATE PUBLIC SYNONYM geometry_columns
    FOR codesys.geometry_columns;
    ```

Spatial Reference Systems

- OGC:

  -
    ```
    CREATE TABLE SPATIAL_REF_SYS (
       SRID INTEGER NOT NULL PRIMARY KEY,
       AUTH_NAME VARCHAR (256),
       AUTH_SRID INTEGER,
       SRTEXT VARCHAR (2048)
    )
    ```
- Oracle:

  -
    ```
    CREATE TABLE
    MDSYS.OGIS_SPATIAL_REFERENCE_SYSTEMS (
       SRID      NUMBER,
       AUTH_NAME VARCHAR2(100),
       AUTH_SRID NUMBER,
       SRTEXT    VARCHAR2(1000),
       SRNUM     NUMBER,
       CONSTRAINT PK_SRID PRIMARY KEY (SRID)
    )
    ```
  - This table is NOT POPULATED and,
  - There is no global view called SPATIAL_REF_SYS based on it.

Spatial Reference Systems

- Oracle does provide the following table:

```
CREATE TABLE MDSYS.SDO_CS_SRS (
  SRID      INTEGER NOT NULL PRIMARY KEY,
  AUTH_NAME VARCHAR2(256),
  AUTH_SRID INTEGER,
  WKTEXT    VARCHAR2(2046),
  CS_NAME   VARCHAR2(80),
  CS_BOUNDS MDSYS.SDO_GEOMETRY )
```

- And associated tables such as:
  - `SDO_DATUMS, SDO_ELLIPSOIDS, SDO_COORD_AXES, SDO_COORD_OPS. etc.`
- Oracle's SRS tables are populated by default.
  - Since 10g Oracle's SRS is based on EPSG.
- There is no global view called SPATIAL_REF_SYS defined on this or the previous table.
- Oracle does not automatically synchronise OGC_SPATIAL_REFERENCE_SYSTEMS as DML is executed against mdsys.SDO_CS_SRS and other tables.

SPATIAL_REF_SYS

- We can, however, create our own SPATIAL_REF_SYS view in Oracle as follows:

  -
    ```
    CREATE VIEW SPATIAL_REF_SYS
    AS
    SELECT SRID,
           AUTH_NAME,
           AUTH_SRID,
           WKTEXT AS SRTEXT
      FROM MDSYS.SDO_CS_SRS;
    ```
- One could create a global synonym for this view as follows:

  -
    ```
    CREATE PUBLIC SYNONYM spatial_ref_sys
    FOR codesys.spatial_ref_sys;
    ```

  -
    ```
    CREATE PUBLIC SYNONYM
    spatial_reference_systems
    FOR codesys.spatial_ref_sys;
    ```

INFORMATION_SCHEMA

- Oracle does not support this aspect of SQL92 standard
  - Needed for some open source software eg ogr
  - Can get a basic implementation from the SourceForge project “Oracle Information Schema” (Lewis Cunningham) at http://sourceforge.net/projects/ora-info-schema/
- This, plus active GEOMETRY_COLUMNS and SPATIAL_REF_SYS objects makes ogr tools like ogrinfo & ogr2ogr work with ODBC driver (don't need compiled OCI version)!

Storage Format and API…

Database Storage Formats...

- Should we care what storage format is used by a database vendor or type manufacturer?
  - While often useful, it is, frankly, **irrelevant**.
  - Chris Date and Hugh Darwen wrote in their book "Foundation for Future Database Systems: The Third Manifesto":
    "What we are saying is that, in the relational world, a domain is a data type, system- or user-defined, whose values *are manipulable solely by means of the operators defined for the type in question* (and whose **internal representation can be arbitrarily complex but is hidden from the user**)." [Emphasis added by myself]
  - No one really worries about how a *number* is *stored* (ie IEEE) within a database as long as we can create, modify, delete and access the data via appropriate languages and standards to a desired precision.

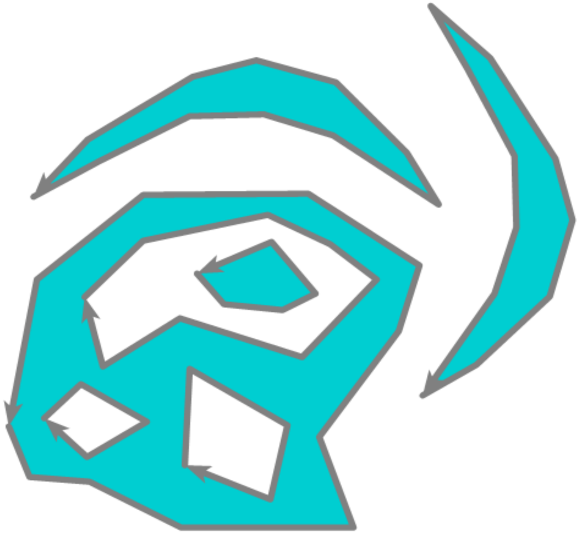
Spatial Database Storage Formats…

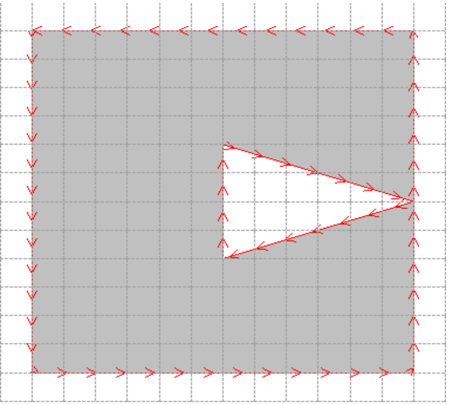
- For those that think storage format matters, PostGIS uses "extended" WKB and Oracle uses openly accessible numbers and arrays (SQL/3 components).
- WKT and WKB are provided primarily as interchange and not storage formats.
- From Standard (SFS 1.2 Part 1 Common Architecture):
  "The Well-known Binary Representation for Geometry (WKBGeometry) provides a portable representation of a geometric object as a contiguous stream of bytes."

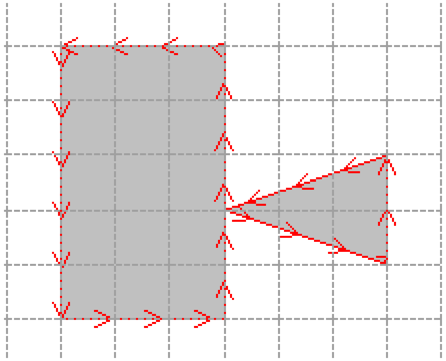
  "The Well-known Binary Representation for Geometry is obtained by serializing a geometric object as a sequence of numeric types drawn from the set {Unsigned Integer, Double} and then serializing each numeric type as a sequence of bytes using one of two well defined, standard, binary representations for numeric types…"

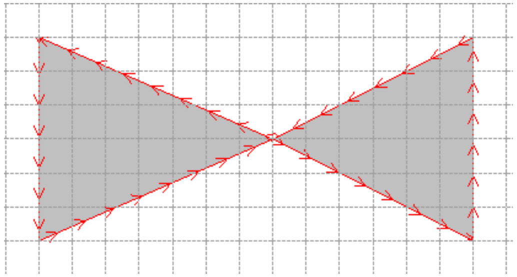
Standards: Orientation & Organisation

- OGC/SQLMM standards also define things like orientation of vertices in a polygon
  - Anti-clockwise for all outer-shells
  - Clockwise for all inner-shells
- And polygon inversion/exversion and bowties









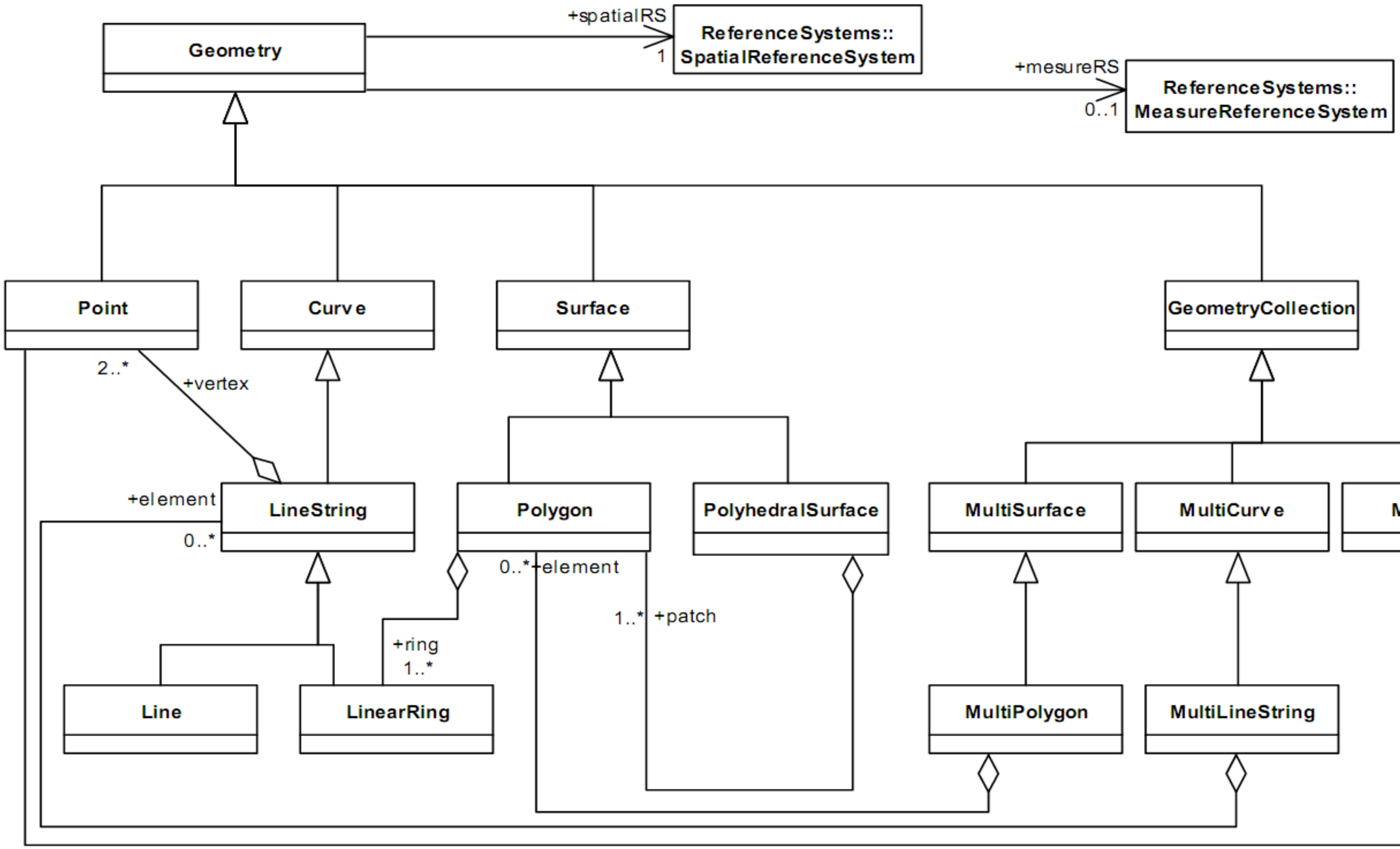
Oracle's Original UDT Implementation …

```
SQL> desc mdsys.sdo_geometry
 Name                                      Null?    Type
 ----------------------------------------- -------- -------------------------
 SDO_GTYPE                                          NUMBER
 SDO_SRID                                           NUMBER
 SDO_POINT                                          MDSYS.SDO_POINT_TYPE
 SDO_ELEM_INFO                                      MDSYS.SDO_ELEM_INFO_ARRAY
 SDO_ORDINATES                                      MDSYS.SDO_ORDINATE_ARRAY

METHOD
------
 MEMBER FUNCTION GET_GTYPE RETURNS NUMBER

METHOD
------
 MEMBER FUNCTION GET_DIMS RETURNS NUMBER

... etc …

METHOD
------
 MEMBER FUNCTION ST_COORDDIM RETURNS NUMBER

METHOD
------
 FINAL CONSTRUCTOR FUNCTION SDO_GEOMETRY RETURNS SELF AS RESULT
 Argument Name                  Type                    In/Out Default?
 ------------------------------ ----------------------- ------ --------
 WKT                            CLOB                    IN
 SRID                           NUMBER                  IN     DEFAULT

... etc …
```

```
SQL> desc sdo_ordinate_array
 SDO_ORDINATE_ARRAY VARRAY(1048576) OF NUMBER
```

- There is no inheritance (no SDO_Polygon, SDO_Point etc)
- Very limited number of methods
- Most "processing" done in PL/SQL packages: SDO_GEOM and SDO_UTIL.

SQLMM Type System / Object Model



Note: Inheritance
Note: Class names in SQL/MM carry a "ST_" prefix. This is *optional* and implementations may chose to drop this prefix.

ISO SQL/MM Part 3 Spatial ADT

```
CREATE TYPE ST_Geometry
AS (
     ST_PrivateDimension                SMALLINT DEFAULT  -1,
     ST_PrivateCoordinateDimension SMALLINT DEFAULT  2,
     ST_PrivateIs3D                     SMALLINT DEFAULT  0,
     ST_PrivateIsMeasured               SMALLINT DEFAULT  0
)
NOT INSTANTIABLE
NOT FINAL

METHOD ST_Dimension()
     RETURNS SMALLINT
     LANGUAGE SQL
     DETERMINISTIC
     CONTAINS SQL
     RETURNS NULL ON NULL INPUT


CREATE TYPE ST_Point
UNDER ST_Geometry AS
(
  ST_PrivateX   DOUBLE PRECISION   DEFAULT NULL,
  ST_PrivateY   DOUBLE PRECISION   DEFAULT NULL,
  ST_PrivateZ   DOUBLE PRECISION   DEFAULT NULL,
  ST_PrivateM   DOUBLE PRECISION   DEFAULT NULL
)
INSTANTIABLE
NOT FINAL
METHOD ST_X()
     RETURNS DOUBLE PRECISION
     LANGUAGE SQL
     DETERMINISTIC
     CONTAINS SQL
     RETURNS NULL ON NULL INPUT
etc
```

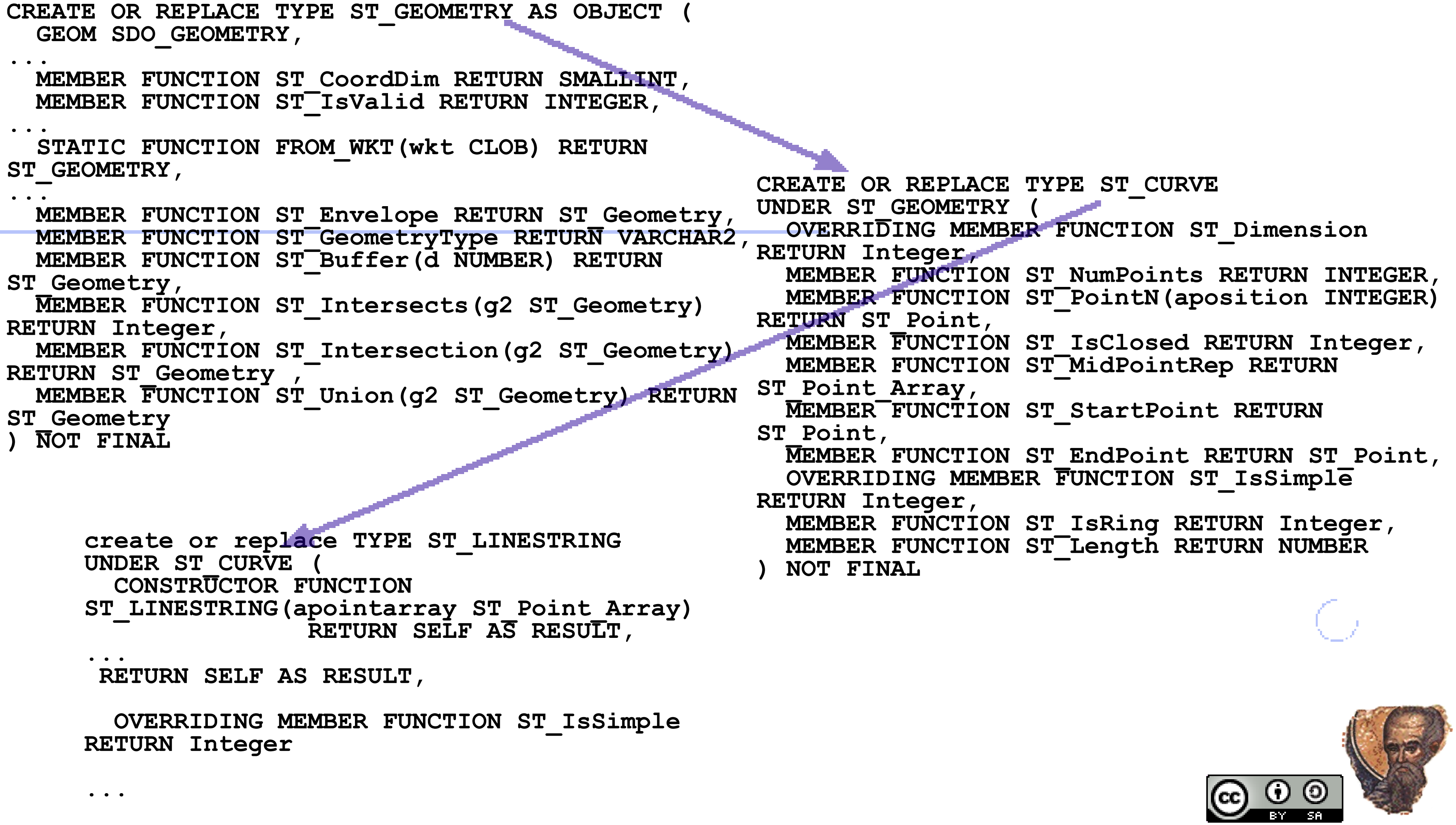
“Standard does not prescribe a particular ADT mechanism, but specifies the behaviour of the ADT through a specification of interfaces that must be supported”

What's in a name

- UDT – User Data Type
- ADT – Abstract Data Type
- Both refer to a data type that extends the SQL type system.
  - Both can define table column types
    - Stored values are instances of the ADT/UDT.
  - SQL functions may be declared to manipulate ADT/UDT values.
- Difference between implementations is important where you want to inherit from the geometry object as required by "ISO Geometry Object Model"
  - ADTs allow sub-typing, UDTs do not.
  - UDTs generally use existing data types for storage, ADTs can create new storage formats.

(Concrete examples soon...)

Oracle's SQL/MM ADT Implementation



```
CREATE OR REPLACE TYPE ST_GEOMETRY AS OBJECT (
  GEOM SDO_GEOMETRY,
...
  MEMBER FUNCTION ST_CoordDim RETURN SMALLINT,
  MEMBER FUNCTION ST_IsValid RETURN INTEGER,
...
  STATIC FUNCTION FROM_WKT(wkt CLOB) RETURN
ST_GEOMETRY,
...
  MEMBER FUNCTION ST_Envelope RETURN ST_Geometry,
  MEMBER FUNCTION ST_GeometryType RETURN VARCHAR2,
  MEMBER FUNCTION ST_Buffer(d NUMBER) RETURN
ST_Geometry,
  MEMBER FUNCTION ST_Intersects(g2 ST_Geometry)
RETURN Integer,
  MEMBER FUNCTION ST_Intersection(g2 ST_Geometry)
RETURN ST_Geometry ,
  MEMBER FUNCTION ST_Union(g2 ST_Geometry) RETURN
ST_Geometry
) NOT FINAL
```

```
CREATE OR REPLACE TYPE ST_CURVE
UNDER ST_GEOMETRY (
  OVERRIDING MEMBER FUNCTION ST_Dimension
RETURN Integer,
  MEMBER FUNCTION ST_NumPoints RETURN INTEGER,
  MEMBER FUNCTION ST_PointN(aposition INTEGER)
RETURN ST_Point,
  MEMBER FUNCTION ST_IsClosed RETURN Integer,
  MEMBER FUNCTION ST_MidPointRep RETURN
ST_Point_Array,
  MEMBER FUNCTION ST_StartPoint RETURN
ST_Point,
  MEMBER FUNCTION ST_EndPoint RETURN ST_Point,
  OVERRIDING MEMBER FUNCTION ST_IsSimple
RETURN Integer,
  MEMBER FUNCTION ST_IsRing RETURN Integer,
  MEMBER FUNCTION ST_Length RETURN NUMBER
) NOT FINAL
```

```
create or replace TYPE ST_LINESTRING
UNDER ST_CURVE (
  CONSTRUCTOR FUNCTION
ST_LINESTRING(apointarray ST_Point_Array)
               RETURN SELF AS RESULT,
...
 RETURN SELF AS RESULT,

  OVERRIDING MEMBER FUNCTION ST_IsSimple
RETURN Integer

...
```

Indexing…

- ST_* search functions like ST_Intersects are NOT indexed in Oracle.
  - Only underlying SDO_Geometry object.
- So…

```
SELECT *
  FROM <table> a
 WHERE a.geometry.ST_Intersects(<search geometry>) = 1;
```

  - Will not use Rtree index.
- But…

```
SELECT *
  FROM <table> a
 WHERE SDO_Filter(a.geometry.geom,<search_geometry>) = 'TRUE'
   AND a.geometry.ST_Intersects(<search geometry>) = 1;
```

  - Will use index and be efficient.

Precision Model...

Precision Model

- An important aspect of Oracle Spatial for PostGIS users is in understanding Oracle's precision model.
- There is a lot written about Oracle's precision model that is wrong. For example:
  - *I come from the ESRI and Oracle world. Both ArcSDE and Oracle Spatial have user-defined spatial tolerance for each spatially enabled layer. This ensures that coordinates are exact, down to the last decimal (or integer for ArcSDE).*
- That Oracle Spatial has a spatial tolerance associated with each sdo_geometry column in a table (which is not a layer) is correct.
- Strictly speaking, as the Oracle documentation points out, a tolerance is **not** the same as coordinate precision!

Precision Model - Continued

- Many think Oracle's tolerance describes the precision of an actual ordinate.
  - That is if the tolerance is 0.05, an ordinate 123.45678 should actually be 123.5.
- However, the Oracle documentation describes tolerance as:

  *"Tolerance reflects the **distance** that two points can be apart and still be considered the same (for example, to accommodate rounding errors)."*
  - This is different from an exact number of digits in an **ordinate**.
- A tolerance of 0.05 means 5cm between two vertices:
  - If the distance between the ordinates is less than that the vertices are considered to be equal.
  - So, if the actual distance between geometries is 0.846049894.
    - An SDO_TOLERANCE value of 0.005 will cause the Oracle SDO_Distance function to return a distance of 0.846049894
    - While an SDO_TOLERANCE value of 0.5 will return 0.0.

- (Oracle's documentation tells users to set tolerances to be half the actual real world tolerance: so, 0.05 means 0.1m. For those who know how rounding is traditionally done in the C language, this is why tolerances are specified in this way.)

Precision Model - Reality

- You can store anything in the number that make up an ordinate of a geometry!

```
SELECT mdsys.OGC_LineStringFromText(
'LINESTRING(1.123456789 1.3445837283728232,
2.4322323534 2.232303998398)',NULL).Get_WKT() |
   as geom
   FROM dual a;

GEOM
-------------------------------------------
LINESTRING (1.123456789 1.3445837283728233,
2.4322323534 2.232303998398)
```

- Oracle has no automatic mechanism for applying the tolerance stored in **USER_SDO_GEOM_METADATA** during transactions such that the ordinates are rounded to a stated precision.
- It is up to your client application or your own programming of triggers to ensure that ordinate precision remains exact: some do, some don't.

Precision Model - Final

- Having said all that, in my programming of Oracle (see my free PL/SQL packages) I actually take the second view in how I handle the comparison of co-ordinates.
  - I prefer to round precisely because when I view the data in textual form (ST_AsText etc) I want to see that it is stored to a stated ordinate (numeric) precision.
  - So, in my packages, I have programmed a function called Tolerance (with wrapper called ST_SnapToGrid) which will round the ordinates to the stated precision.
- In the following, you will note that I can construct a geometry with any number of digits but you have to write a function yourself to round them to your data's actual precision (in this case 1cm):

```
SELECT ST_GEOM.ST_SnapToGrid(a.geom,0.005).GET_WKT() as geom
  FROM (SELECT mdsys.OGC_LineStringFromText(
   'LINESTRING(1.12345 1.3445,2.43534 2.03998398)',NULL) as geom
          FROM dual) a;
```

```
GEOM
-------------------------------------
LINESTRING (1.12 1.34, 2.44 2.04)
```

- To do this is PostGIS you need to use use ST_SnapToGrid():

```
SELECT ST_AsText(ST_SnapToGrid(a.geom,0.05,0.05)) as geom
  FROM (SELECT ST_GeomFromText(
                      'LINESTRING(1.12345 1.3445,2.43534 2.03998398)',
                      0)
               as geom) a;

geom
text
------------------------
LINESTRING(1.1 1.35,2.45 2.05)
```

Programming...

Cross-Platform Porting....

- I do all my programming of Oracle using PL/SQL and the standard SDO_Geometry data type.
- However, it is perfectly possible to minimise the effort required when switching between Oracle and PostGIS.
  - For example, if we want the first vertex of a linestring geometry in Oracle (no native Oracle function):

```
SELECT MDSYS.SDO_GEOMETRY(2001,NULL,
                          SDO_POINT_TYPE(v.x,v.y,v.z),NULL,NULL)
       as first_point
  FROM TABLE(
         MDSYS.SDO_UTIL.GETVERTICES(
           MDSYS.SDO_GEOMETRY(2002,NULL,NULL,
                              MDSYS.SDO_ELEM_INFO_ARRAY(1,2,1),
                              MDSYS.SDO_ORDINATE_ARRAY(1,1,2,2)))
          ) v
 WHERE rownum < 2;
```

  - With PostGIS this is easy – use the ST_StartPoint function:

```
SELECT ST_AsText(ST_StartPoint(ST_LineFromText('LINESTRING(1 1,2
2)',28355)));
```

Cross Platform (2)

- How do we bring these two approaches together?
  - Well, one way is to use Oracle's ST_Geometry implementation as it contains an ST_StartPoint method:

```
SELECT MDSYS.OGC_AsText(mdsys.OGC_LinestringFromText('LINESTRING(1 1,2 2)',28355).ST_StartPoint())
  FROM DUAL;

or

SELECT TREAT(MDSYS.ST_Linestring.From_WKT('LINESTRING(1 1,2 2)',28355)
               as MDSYS.ST_LineString).ST_StartPoint().Get_WKT()
  FROM dual;
```

  - But what if the function doesn't exist in Oracle's SQL/MM implementation e.g. PostGIS's ST_RemovePoint?

```
geometry ST_RemovePoint(geometry linestring, integer offset);
```

  - Then I use PL/SQL to implement a function.
    - I use native Oracle methods to implement the function but
    - I include two overloaded methods:
      - One for the native SDO_Geometry type
      - The other using Oracle's ST_Geometry type

Cross Platform (3)

-
  ```
  CREATE OR REPLACE PACKAGE GEOM
  AUTHID CURRENT_USER
  AS
  …
    Function SDO_RemovePoint(p_geometry  IN MDSYS.SDO_Geometry,
                             p_position  IN Number)
      Return MDSYS.SDO_Geometry Deterministic;

    Function ST_RemovePoint(p_geometry  IN MDSYS.ST_Geometry,
                            p_position  IN Number)
      Return MDSYS.ST_Geometry Deterministic;

  …
  END Network;
  ```

-
  ```
  CREATE OR REPLACE PACKAGE BODY GEOM
  AS
  …
    Function ST_RemovePoint(p_geometry  IN MDSYS.ST_Geometry,
                            p_position  IN Number)
      RETURN MDSYS.ST_Geometry
    Is
    Begin
      Return MDSYS.ST_Geometry.FROM_SDO_GEOM(
                      SDO_RemovePoint( p_geometry.GET_SDO_GEOM(),
                                       p_position ));
    End ST_RemovePoint;
  ```
- Where **SDO_`RemovePoint`** is the function that is written using native SDO_Geometry processing and methods.

Dot Notation...

- PostGIS is not implemented as an inheritable type system so one executes methods on a geometry object as follows:

```
SELECT ST_Length(ST_LineFromText('LINESTRING(1 1,2 2)',28355));
```

- With Oracle, if you use the ST_* type system you have to use “dot”notation:

```
SELECT mdsys.OGC_LineStringFromText(
          'LINESTRING(1 1,2 2)',28355).ST_Length()
  FROM DUAL;
```

- But if you use the ordinary SDO_Geometry, while there are a limited set of methods for the type most processing is done using utility functions.

```
SELECT mdsys.sdo_geom.Sdo_Length(mdsys.sdo_geometry(
           'LINESTRING(1 1,2 2)',28355),0.05)
  FROM DUAL;
```

Hiding names....

- Don't like “mdsys.sdo_geom.sdo_length”? Then hide it:

```
create function ST_Length( p_geometry  in sdo_geometry,
                           p_tolerance in number )
 return number DETERMINISTIC
As
Begin
  Return
mdsys.sdo_geom.sdo_length(p_geometry,p_tolerance);
End ST_Length;
```

- Which you can use as follows:

```
SELECT ST_Length(sdo_geometry('LINESTRING(1 1,2
2)',28355),0.05)
  FROM DUAL;
```

- This “looks” a lot more like PostGIS
- Could be done for all Oracle packaged functions that are functionally the same.

ST_* Issue...

- Now, when one database implements things “properly” the other causes “problems”.
- For example, in Oracle the SQL/MM functions ST_GeometryN() and ST_NumGeometries() does not exist!
- In PostGIS one would like to write (but can't):

```
SELECT ST_GeometryN(m.mline,p.*) as Line
  FROM (SELECT ST_MLineFromText(
                 'MULTILINESTRING((1 1,2 2),(3 3,4 4))',
                 28355) as mline
       ) m,
       generate_series(1,ST_NumGeometries(m.mline),1) p;
```

- One can do this in Oracle because they have implemented an ST_Geometries method in ST_Geometries that returns an array of Geometries:

-
  ```
  SELECT b.*
    FROM TABLE(SELECT a.geom.ST_Geometries()
                 FROM (SELECT mdsys.OGC_MultiLineStringFromText(
                  'MULTILINESTRING((1 1,2 2),(3 3,4 4))', 28355)
                              as geom
                         FROM dual) a
               ) b;
  ```
- This plays to Oracle's strengths but isn't an implementation of the SQL/MM standard.

Complain or....

- To the lack of ST_GeometryN and OGC_MultiLineStringFromText we can:
  - Complain....
  - Or do something about it.
- Do the former, but implement the latter:

```
create or replace function ST_GeometryN
       ( p_geometry in mdsys.ST_GeomCollection,
         p_num       in integer )
  return mdsys.st_geometry deterministic
as
  v_geom mdsys.st_geometry;
begin
  SELECT c.geom
    INTO v_geom
    FROM (SELECT rownum as rin,
                 mdsys.ST_Geometry.From_SDO_Geom(g.geom)
                    as geom
            FROM TABLE(SELECT p_geometry.ST_Geometries()
                         FROM DUAL
                       ) g
          ) c
   WHERE rin = p_num;
  RETURN v_geom;
  EXCEPTION
    WHEN NO_DATA_FOUND THEN
       RETURN NULL;
end ST_GeometryN;
```

Complain (2)...

- ST_NumGeometries:

```
Create Function ST_NumGeometries (
                      p_geometry in mdsys.ST_GeomCollection )
  Return Integer Deterministic
As
  v_count integer;
Begin
  SELECT count(*)
    INTO v_count
    FROM TABLE(SELECT p_geometry.ST_Geometries() FROM DUAL) g;
  RETURN v_count;
  EXCEPTION
    WHEN NO_DATA_FOUND THEN
       RETURN NULL;
End ST_NumGeometries;
```

- Throw in some public synonyms:

```
create public synonym ST_LinestringFromText
for mdsys.OGC_LinestringFromText;

create public synonym ST_MultiLinestringFromText
for mdsys.OGC_MultiLinestringFromText;
```

- And it all starts to look just a bit... familiar!

```
SELECT ST_GeometryN(b.mline,n.column_value)
  FROM (SELECT ST_MultiLineStringFromText(
                     'MULTILINESTRING((1 1,2 2),(3 3,4 4))',
                     28355)
                 as mline
          FROM dual ) b,
       TABLE(codesys.geom.generate_series(1,
                            ST_NumGeometries(b.mline),1)) n;
```

Complain (3)

- Oracle's implementation of ST_Geometry is declared NOT FINAL so, theoretically, it would be possible to extend the type system as follows:

```
ALTER TYPE mdsys.ST_GeomCollection CASCADE
ADD MEMBER FUNCTION
ST_GeometryN ( p_geometry in mdsys.ST_GeomCollection,
               p_num in integer )
  RETURN  mdsys.ST_Geometry DETERMINISTIC,
ADD MEMBER FUNCTION
ST_NumGeometries ( p_geometry in  mdsys.ST_GeomCollection )
  RETURN Integer DETERMINISTIC;
```

- But one might meet support issues with Oracle.

Framework/Database issues….

- Programmatic problems often have nothing to do with the spatial data type.
- For example, one can, in a SELECT statement, in PostGIS you cannot call a function (generate_series) using the values from a table (m).

```
SELECT ST_PointN(m.line,p.*) as point
  FROM (SELECT ST_LineFromText('LINESTRING(1 1,2 2)',28355)
                  as mline
       ) m,
       generate_series(1,ST_NPoints(m.mline),1) p;
```

- As you get this error (what is called “Functional Row Expansion”):

```
ERROR: function expression in FROM cannot refer to other
relations of same query level
```

- Whereas, in Oracle, this is not a problem:

```
SELECT a.geom.ST_PointN(g.COLUMN_VALUE)
  FROM (SELECT mdsys.OGC_LineStringFromText(
                  'LINESTRING(1 1,2 2)', 28355)
                  as geom
          FROM dual
       ) a,
       TABLE(codesys.geom.generate_series(
                    1,a.geom.ST_NumPoints(),1)) g
```

Issues (2)

- pg/PLSQL is like PL/SQL but it is not the same!
- Can't overload functions/procedures in Oracle as you can in PostgreSQL
  - PACKAGEd functions can be overloades
    - Only EnterpriseDB has packages!
- Casting is a part of life in PostGIS but you can only do it via the CAST() SQL function in Oracle.
- SELECT … FROM **DUAL**;
- CHECK constraint limitations (can't do this in Oracle):
  - CHECK (ST_Area(the_geom) > 10)
- SQL Analytics, rownum, TABLE() ….
- Materialised Views, Schemas/Tablespaces…
- Redo and undo logs, nologging, direct path inserts…
  - The list is endless!

Open/Closed Source...

- Oracle may be closed source but your code can be open source...
  - I make my PL/SQL code available for free.
- Lewis's INFORMATION_SCHEMA on SourceForge is a good example.
- So, share it around!

Summary…

- To know how to port from one database to the other or support both in a production environment demands knowledge of each product.
- The rich set of tools any database provides offers much scope for improving portability: views, functions, synoynms etc.
- I have given you some methods for increasing portability of the spatial side of Oracle/PostGIS;
  - Synonyms, views, function wrappers, ST_* type etc;
- However, the majority of issues are not spatial
  - The spatial “design pattern” is pretty standard, it's just the names used that cause “problems”!
  - Major issues are endemic:
    - i.e., fundamentally a part of a database's architecture.

Questions...

- Thank you for being patient....

Any questions?