Modeling Techniques for Transportation Data Models
An Open, Standards Based Object-Relational Database Management Systems (ORDBMS) Approach

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Agenda

• Who is Acquis Business Intelligence?
• Acquis BI R&D Process
• Present logical->relational design of Transportation Data Model and Physical Model creation
• Present Utah DOT data implementation in the data model
• How to get the model?
• Q&A
Acquis BI

• Oracle “Gold” Level Business Partner
• Specialize in Oracle implementations
  – ‘anything’ Spatial, BI/OBIEE, data modeling, data driven applications and API’s
  – Transportation, Utilities, Fed, State, Local Gov’t Markets
Research and Development Lab

• Think tank
  – Brainstorm exercises surrounding projects, customers, business problems and technologies
  – *What are the business problems?*

• Technology research implementation environment
  – *What technology exists today?*
  – “Seed” level implementations (solutions targeted at the “birth” of the problem)
Business Problems

- Many highly specialized, disparate data sources and business systems
- Many “custom” processes for Extract, Transform, Load (ETL) and data integration to get the right data to the right personnel (repeated and error prone)
- Maintenance in many different business units (validation, business rules and integrity are “spread out”)
- The data is extremely complex (topological, hierarchical, LRS/mLRM, networked, etc)
- Data and business services serve a very large array user with different business needs
- Data is difficult to access. Offsite customers, through the web or web services, mobile requirements, portable “in the field” requirements
- Spatial is just a component. Business needs are financials, project management/planning, forecasting, reporting, business intelligence and data mining
Think Tank Results

- Open, standards based, non-proprietary data
  - The data model must be transparent, open and free of third party licensing to all systems in any development language on any platform at any “tier”
- Easily accessible (desktop, web, mobile)
- Temporal (multi-dimensional)
- Multi-Modal (roads, railroads, subways, etc)
- Topological
- mLRM’s
- Multi-dimensional BUSINESS Model, spatial is a component
- Highly Scalable, “any” platform support

Highest Value Implementation - A DATA MODEL
The Data Model Technical Decisions

- **Oracle with Spatial Cartridge**
  - Supports topology, LRS, Networking (simple feature model only in other DB’s spatial capabilities)
  - SQL/JAVA API for all features

- **SQL Developer Data Modeler**
  - Free, easily accessible and no license required
  - Supports modeling of complex data types (i.e. spatial objects)
  - Integrated with source control (multi-user development)
  - Logical (design) <-> Relational (engineer) <-> Physical model (auto-create)
Oracle Topology Basics

- Edge, Node and Face Topological Primitives (stored as SDO_GEOMETRY)
- Topological Relationships are stored in tables
- Topological Features stored as SDO_TOPO_GEOMETRY
- Hierarchical feature modelling, level 0 features compose level 1 features. Level 1 features compose Level 2 features, etc, etc.
- SQL API (manage at the DB tier)
- JAVA API (manage at any tier)
Oracle LRS Basics

- Adds dimension M to ELEMENT_INFO of an SDO_GEOMETRY
- Supports dynamic creation of LRS geometry from “source” geometry
- Supports measure populating and scaling
- Locate and project point on LRS geometry (with offset support)
- Redefine, splitting, concatenating, etc
- SQL and JAVA API
Oracle Network Basics

• Network Nodes and Links
• Paths, Sub-paths and Connected Components
• Network model metadata
• Shortest path (distance or cost), travelling salesman, within cost, reachable nodes, etc.
• SQL, Java and SOAP web service API
BI Metadata Repository Basics

- Physical Model->Business Model->Presentation Model Metadata Repository
- Multidimensional (* Schema)
- Human readable Presentation Model
- Easily compose any business “analysis” from presentation objects
- Interact with a presentation objects, not tables, columns and rows.
Logical Design Legend

**Inheritance Object** – object defining properties inherited by child object(s). Children objects display “within” parent Inheritance Object.

**Topology Feature Layer Table** – Table represented in the Oracle topology hierarchy. Contains SDO_TOPO_GEOMETRY column.

**Fact Table** – Oracle table representing some any type of fact object.

**Geometry Table** – Oracle table representing some type of fact. Contains SDO_GEOMETRY column.

One to Many relationship

One to One Identifying relationship
Main Components:
1. Topology Hierarchy
2. Location (LRM and Geo-Position)
3. Calibration Points
4. Assets
5. Events
Logical Spatial Representation

Level 0 Topology LAYERS

Level 1 Topology Layers

Level 2 Topology Layers

Location
Logical Calibration Point Representation

**Calibration Points have Geometry (SDO GEOMETRY)**

- Calibration Points have 1..n LRM\_POSITION

**Calibration Points have GEO\_POSITION**

- Stores any “type” of Calibration Point (Reference Marker, Mile Marker, MileLog, etc)

Enables transformation between LRM’s.
Logical Assets Representation
Logical Event Representation

EVENTS_SUBVIEW (Temporal_Multi-Modal_Transportation_Model_v1)

LOCATION
- RECORD_DATE
- RECORD_STATUS
- ENTITY_STATUS
- FROM_DATE
- TO_DATE
- NOTES

LRM_POSITION
- * LRM_POSITION_ID
- LRM_TYPE
- ROADWAY_ID
- FROM_MEASURE
- TO_MEASURE
- MILE_LENGTH
- SIDE_OF_ROAD
- OFFSET_REFERENT
- OFFSET_DIRECTION
- POSITION_STATUS
- SOURCE

GEO_POSITION
- * GEO_POSITION_ID
- DATUM
- POSITION_STATUS
- X_COORD
- Y_COORD
- Z_COORD

EVENTS
- RECORD_DATE
- FROM_DATE
- TO_DATE
- RECORD_STATUS
- ENTITY_STATUS
- NOTES

EVENT
- * EVENT_ID

ATHWLD
- * ATHWLD_ID_ID
- CURRENT_YEAR
- PCT_TANDEM_AXLE_DESIGN_YR
- DESIGN_YEAR

CRASH
- * CRASH_ID
- DISTANCE
- CRASH_TYPE
- CRASH_DESCRIPTION
- CRASH_DATE
- NUMBER_INJURED

CURVE
- * CURVE_ID
- CURVE_CLASSIFICATION
- HORIZONTAL_ALIGNMENT

HIGHWAY_STATUS
- * HIGHWAY_STATUS_ID
- HIGHWAY_STATUS_DATE
- HIGHWAY_STATUS_NOTE
Relational Model Engineering
CREATE TABLE AADT_ESTIMATE
{
    RECORD_DATE TIMESTAMP (0) WITH TIME ZONE ,
    FROM_DATE TIMESTAMP (0) WITH TIME ZONE ,
    TO_DATE TIMESTAMP (0) WITH TIME ZONE ,
    RECORD_STATUS NUMBER CHECK ( RECORD_STATUS IN (0, 1, 2, 3, 4, 5, 6, 7) ) ,
    ENTITY_STATUS NUMBER CHECK ( ENTITY_STATUS IN (1, 11, 12, 2, 21, 3, 31, 32, 33, 34, 35, 4, 5, 6, 7, 86) ) ,
    NOTES VARCHAR2 (112) ,
    AADT_ESTIMATE_ID NUMBER (36) NOT NULL ,
    TRAFFIC_SECTION_ID NUMBER (38) ,
    ESTIMATE_YEAR_DATE ,
    AADT NUMBER (10) ,
    E_FACTOR NUMBER (6,3) ,
    T_FACTOR NUMBER (6,3) ,
    P_FACTOR NUMBER (6,3) ,
    GROWTH_FACTOR NUMBER (6,3) CHECK ( GROWTH_FACTOR IN (1, 2, 3, 4, 5) ) ,
    ASSET_ID NUMBER (38) NOT NULL
}

COMMENT ON TABLE AADT_ESTIMATE IS 'AADT is a theoretical estimate of the total number of vehicles using a specific segment of roadway (in both directions) on any given day of the year. This estimate represents the total number of cars per year divided by 365 and is developed using factors to adjust for season, day of the week, and vehicle type.';

CREATE UNIQUE INDEX AADT_ESTIMATE_ID ON AADT_ESTIMATE
{
    ASSET_ID ASC
}

ALTER TABLE AADT_ESTIMATE
ADD CONSTRAINT AADT_ESTIMATE_PK UNIQUE ( AADT_ESTIMATE_ID ) ;

CREATE TABLE ASSET
{
    RECORD_DATE TIMESTAMP (0) WITH TIME ZONE ,
    FROM_DATE TIMESTAMP (0) WITH TIME ZONE ,
    TO_DATE TIMESTAMP (0) WITH TIME ZONE ,
    RECORD_STATUS NUMBER CHECK ( RECORD_STATUS IN (0, 1, 2, 3, 4, 5, 6, 7)) ,
    ENTITY_STATUS NUMBER CHECK ( ENTITY_STATUS IN (1, 11, 12, 2, 21, 3, 31, 32, 33, 34, 35, 4),
    NOTES VARCHAR2 (112) ,
    ASSET_ID NUMBER (38) NOT NULL ,
    ASSET_TYPE VARCHAR2 (30)
}
Utah Concrete Example

- State of Utah provides GIS data free for download
  the Utah GIS Portal: [http://gis.utah.gov/download](http://gis.utah.gov/download)
- Download ROADS and Route Calibration Points.
- Imported Shapefiles to Oracle DB Using MapBuilder
- Transform and Load (TL) simple features into
  Transportation Data Model
Road Topology
LRS/LRM Process

• Utilize the LRS API of Oracle Spatial
• Procedures:
  – All Routes (and Road Segments) have FROM_MEASURE, TO_MEASURE, MEASURE_METHOD attributes
  – Two calibration methods
    • Calibrated (using Route Reference Marker Calibration Points)
    • Calculated (using cartographic length)
  – Dynamically create LRS Geometry (X,Y,M)
  – Perform Dynamic Segmentation
  – Persist and Display
## LRS/LRM Example

```sql
SELECT ae.ADT_ESTIMATE_ID, l.FROM_MEASURE, l.TO_MEASURE, SITE_ID, DESCRIPTION, AADT, AADT_GROWTH FROM LRM_POSITION l
INNER JOIN asset a ON l.asset_id-a.asset_id JOIN AADT_ESTIMATE ae ON ae.ASSET_ID=a.ASSET_ID WHERE ae.ROUTE='0171' AND ESTIMATE_YEAR='01-MAR-06';
```

<table>
<thead>
<tr>
<th>AADT_ESTIMATE_ID</th>
<th>FROM_MEASURE</th>
<th>TO_MEASURE</th>
<th>SITE_ID</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>14879</td>
<td>0</td>
<td>1.498</td>
<td>90544</td>
<td>SR 111 S400 West Magna</td>
</tr>
<tr>
<td>14882</td>
<td>3.508</td>
<td>4.511</td>
<td>90551</td>
<td>7200 West via 3500 South</td>
</tr>
<tr>
<td>14885</td>
<td>4.511</td>
<td>5.513</td>
<td>90556</td>
<td>SR 172 5600 West</td>
</tr>
<tr>
<td>14888</td>
<td>5.513</td>
<td>6.015</td>
<td>90560</td>
<td>4800 West via 3500 South</td>
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<tr>
<td>14874</td>
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<td>6.015</td>
<td>90561</td>
<td>4000 West</td>
</tr>
<tr>
<td>14877</td>
<td>6.015</td>
<td>6.52</td>
<td>90562</td>
<td>SR 154 Bangerter Highway</td>
</tr>
<tr>
<td>14880</td>
<td>6.52</td>
<td>7.02</td>
<td>90563</td>
<td>3600 West via 3500 South</td>
</tr>
<tr>
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<td>7.327</td>
<td>90564</td>
<td>3200 West</td>
</tr>
<tr>
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<td>7.327</td>
<td>8.022</td>
<td>90565</td>
<td>2700 West via 3500 South</td>
</tr>
<tr>
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<td>8.022</td>
<td>8.721</td>
<td>90566</td>
<td>I 215</td>
</tr>
<tr>
<td>14892</td>
<td>8.721</td>
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<td>90567</td>
<td>SR 68 Redwood Road via 3500 South</td>
</tr>
<tr>
<td>14895</td>
<td>10.007</td>
<td>10.131</td>
<td>90568</td>
<td>900 West</td>
</tr>
<tr>
<td>14898</td>
<td>10.131</td>
<td>10.731</td>
<td>90569</td>
<td>I 15 via 3300 South</td>
</tr>
<tr>
<td>14901</td>
<td>10.731</td>
<td>11.327</td>
<td>90570</td>
<td>300 West</td>
</tr>
<tr>
<td>14904</td>
<td>11.327</td>
<td>11.621</td>
<td>90571</td>
<td>SR 80 State Street via 3300 South</td>
</tr>
<tr>
<td>14907</td>
<td>11.621</td>
<td>11.93</td>
<td>90572</td>
<td>900 East</td>
</tr>
<tr>
<td>14910</td>
<td>11.93</td>
<td>12.533</td>
<td>90573</td>
<td>SR 71 700 East via 3300 South</td>
</tr>
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<td>12.709</td>
<td>90574</td>
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<td>90575</td>
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<td>15.06</td>
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<td>2300 East</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>90584</td>
<td>2700 East - I 215</td>
</tr>
</tbody>
</table>

23 rows selected
Network Example
Top 6 Advantages:

• Removes all data silos
• Reduces IT complexity, licensing and cost
• Open to any API through simple db drivers (JDBC, ODP.NET, etc)
• One, open standards based database and access point
• Comprehensive customization deployment options (Extensive capabilities within the DB tier, SQL Packages, Procedures, deployed JAVA)
• Simple SQL Language access (lower skillset required for customization and of complex use cases)
Data Model Availability and Download

- Open Source and Free for DOT Community
- Oracle DB Enterprise with Spatial Cartridge
  - Free to download and create development environment
- Contains:
  - SQL Developer Data Modeler Project
    - Logical Diagram
    - Physical Diagram
    - Topology and Network Registration Scripts
    - Sample Utah data loading scripts
    - Oracle Dumps of Utah data loaded into data model
    - Sample SQL Scripts to demonstrate topological interaction, LRS/LRM (dynamic segmentation), networking, etc.

- Download at: http://www.acquisbi.com
Questions

Question and Answers Session