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Oracle Spatial and Graph: Faster, Bigger, Better 2-D and 3-D Spatial Solutions

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HARDWARE AND SOFTWARE ENGINEERED TO WORK TOGETHER

Program Agenda

- Spatial and Graph 12c
  - Performance Improvements
  - Ease of Use Features
  - Support for 3D Applications
  - GeoRaster
  - Network Data Model
- MapViewer 11.1.1.7.X

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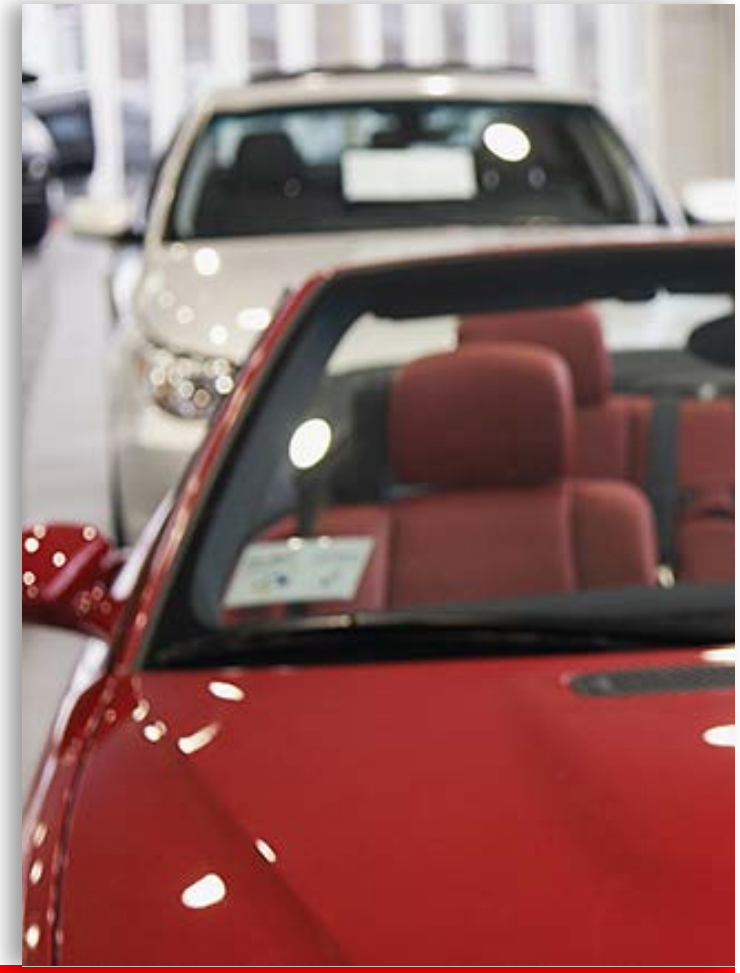
Performance Enhancements



Faster Functions

- New algorithms implemented for many commonly used Spatial functions like RELATE and VALIDATE
  - SDO_GEOM.RELATE - Gains seen for all masks (5x to 10x faster)
  - VALIDATE_GEOMETRY - Up to 4 times faster
  - AGGREGATE UNION – Up to 10x faster
  - SDO_DISTANCE – Up to 10x faster
  - SAM_CLUSTERS – Up to 10x times faster

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SQL Caching

- Kernel level caching for most common SQL queries
  - Geometry metadata
  - Index metadata
  - Coordinate System queries
- Database level caching
  - Sessions can share the cached results

SQL Caching Performance gains

- Substantial Performance gains for DMLs
  - Reduces the total time for each DML operation
- Spatial Operators are faster
  - Optimization especially noticeable in workflows with many fast running queries
- Coordinate System Transformations are faster
  - With EPSG model, we read data from many tables during transformation process

Parallel Index and Functions

- Improved the code so that more tasks can be parallelized
  - Tested with up to 32 CPUs
- Most of the Spatial functions enabled for parallel query
  - Validate_Geometry
  - Relate
  - Union and Intersection
  - Many other functions

New PointInPolygon Function

Fast Point in Polygon without Spatial index

- SDO_PointInPolygon Function
  - Arg1: cursor that select a set of points
    - Very flexible as the data can come from a table, or result of another query
    - E.g., select * from point_data where c1 < 10 and c2 > 100 …
  - Arg2: is any Polygon geometry
  - Returns all the points that are inside the polygon
- Useful when large number of points have to be classified based on a set of polygons
- Parallel enabled
- Can easily process 30K points per second in serial case

Vector Performance Acceleration (VPA)

- Is the name for a **collection of performance improvements**
- Only available for **Oracle Spatial** (not Oracle Locator)
- Needs the SPATIAL_VECTOR_ACCELERATION **parameter** to be set.
- Set at session or system level
- Fully dynamic
- FALSE by default

```
alter session set spatial_vector_acceleration = true;
```

```
alter system set spatial_vector_acceleration = true;
```

Vector Performance Acceleration

"Turbo-charger" feature for spatial functions and operations

What is covered under VPA

- These Performance Improvements are only in Spatial with VPA
  - SQL Caching
  - RELATE Functions
  - All operators except
    - ayinteract, inside, sdo_nn, sdo_within_distance
  - SDO_JOIN
  - Union operations (AggregateUnion, SDO_UNION, AGGRSETUNION)
- All other improvements are available to Locator

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Example: Metadata Reduction

```
SELECT p.id, p.name
  FROM us_parks p, us_states s
 WHERE s.state = 'Wyoming'
   AND SDO_INSIDE (p.geom, s.geom) = 'TRUE'
```

```
SELECT sdo_diminfo, nvl(sdo_srid, -1)
FROM MDSYS.SDO_GEOM_METADATA_TABLE
WHERE SDO_OWNER = :own AND SDO_TABLE_NAME = nls_upper(:tab) AND SDO_COLUMN_NAME = nls_upper(:col)
```

Without VPA

call	count	cpu	elapsed	disk	query	current	rows
Parse	12747	0.32	0.50	0	0	0	0
Execute	12747	0.40	0.61	0	0	0	0
Fetch	12747	0.46	0.80	0	25494	0	12747
total	38241	1.19	1.91	0	25494	0	12747

With VPA

call	count	cpu	elapsed	disk	query	current	rows
Parse	2	0.00	0.00	0	0	0	0
Execute	2	0.00	0.00	0	0	0	0
Fetch	2	0.00	0.00	0	4	0	2
total	6	0.00	0.00	0	4	0	2

Example: Aggregation

- Aggregate all 3230 counties and fuse them into a single polygon

```
SELECT sdo_aggr_union(sdoaggrtype(geom,0.5))
FROM us_counties;
```

Elapsed: 00:26:57.21	Without VPA
Elapsed: 00:00:12.56	With VPA

- Other techniques no longer needed
  - Recursive aggregation (complex queries)
  - Using SDO_AGGR_SET_UNION

Elapsed: 00:01:18.28
Elapsed: 00:00:26.89

Ease of Use Features

Optimizer Hints for Spatial queries

Improve Execution plans for Spatial queries

- Issues with 11gR2
  - Execution plans are not very accurate when non-spatial predicates are combined with spatial predicates
  - Execution plans are not optimal for many JOIN cases
  - Requires user supplied optimizer hints
- Application generated queries are not necessarily tuned with hints

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Spatial Data Statistics Collection

- Statistics collection depends on an existing R-tree index
- Execution of dbms_stats invokes spatial statistics collection algorithms and forms the MDXT_%OBJID%$ table
  - DBMS_STATS.GATHER_INDEX_STATS(….)
  - DBMS_STATS.GATHER_SCHEMA_STATS(….)
- Selectivity estimates at run time
  - Low query execution overheads in conducted experiments
- Estimated selectivity and actual selectivity is very close in most of the cases
- Ability to select better execution plans even between plans having small differences in actual execution times!

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Redo Reduction

- R-tree index nodes are stored as LOBs
- Lobs produce lot of redo when updated
- During DML operations, spatial index nodes get updated many times
- We now use better delayed write methods to reduce the number of times each node is updated on the disk
- Big improvements seen with customer data sets
  - 90% reduction in I/O in some cases
  - Up to 50% improvement in transaction times for most cases

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Logical Standby and Replication

- Logical Standby supports SDO_GEOMETRY
  - No special work-around required
  - DDL, DML, geometry and index metadata supported
  - GeoRaster, Topology and NDM planned for next release
- Replication
  - Streams and Advanced replication are in support mode
  - Golden Gate is the supported feature for replication
    - Golden Gate supports all the spatial types
- New XStreams feature in 12c for client-to-database replication
  - Supports SDO_GEOMETRY

Simplified Java API for 2D and 3D

- SDOAPI contains an in memory R-Tree for primary filter operations
- New SDOAPI functions, enhanced to support the following in-memory operations
  - Distance
  - Inside
  - AnyInteract
- New in memory functions support the following geometries types
  - Projected 2D and 3D
  - Geodetic 2D and 3D
  - Cricular and NURB curve types

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SQL Developer

- Fully integrated support for SDO_GEOMETRY
- Metadata data management via the GUI
- Visualization of Geometry
- Next version in development
  - Better support for overlays of geometries
  - More options for visualization styles
- What is the future ?
  - Support GeoRaster, Topology and other types ?
  - Need feedback

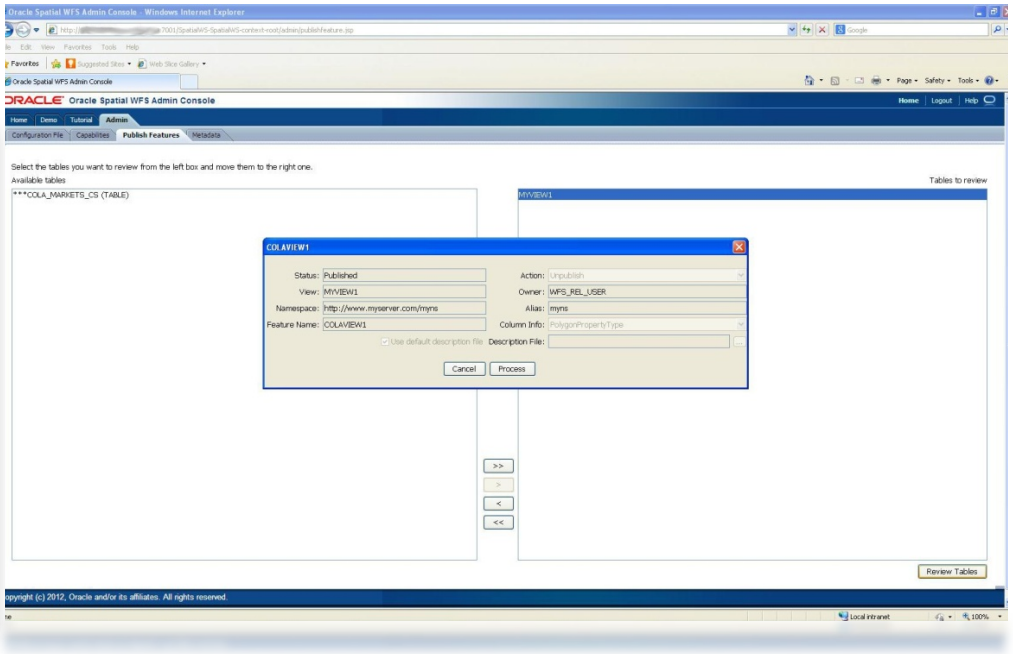
Web Feature Server

- Supports tables with SDO_GEOMETRY column
- Publish any SDO_GEOMETRY column as a feature
- WFS with transactions
- Built as a J2EE application
- Supported J2EE containers
  - WLS
  - GlassFish

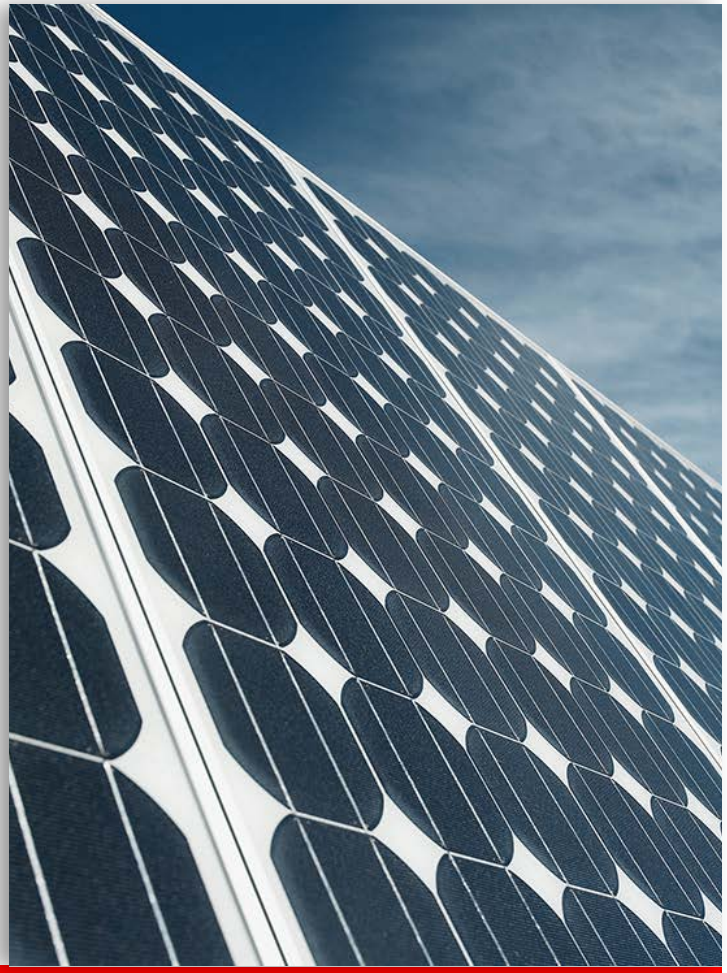
Web Feature Server 1.1

Web-based Administrative console

- Menu driven GUI simplifies registration of spatial layers with Oracle Spatial and Graph's WFS
  - Browse existing spatial layers
  - Eliminates the need for DBA to run PL/SQL scripts to publish spatial layers
- Includes tutorial on how to configure and use WFS
- Provide sample request and response pages for WFS queries
- Can also be used as a client to other WFS servers
  - In this mode, only browsing options are enabled



Support for 3D Applications



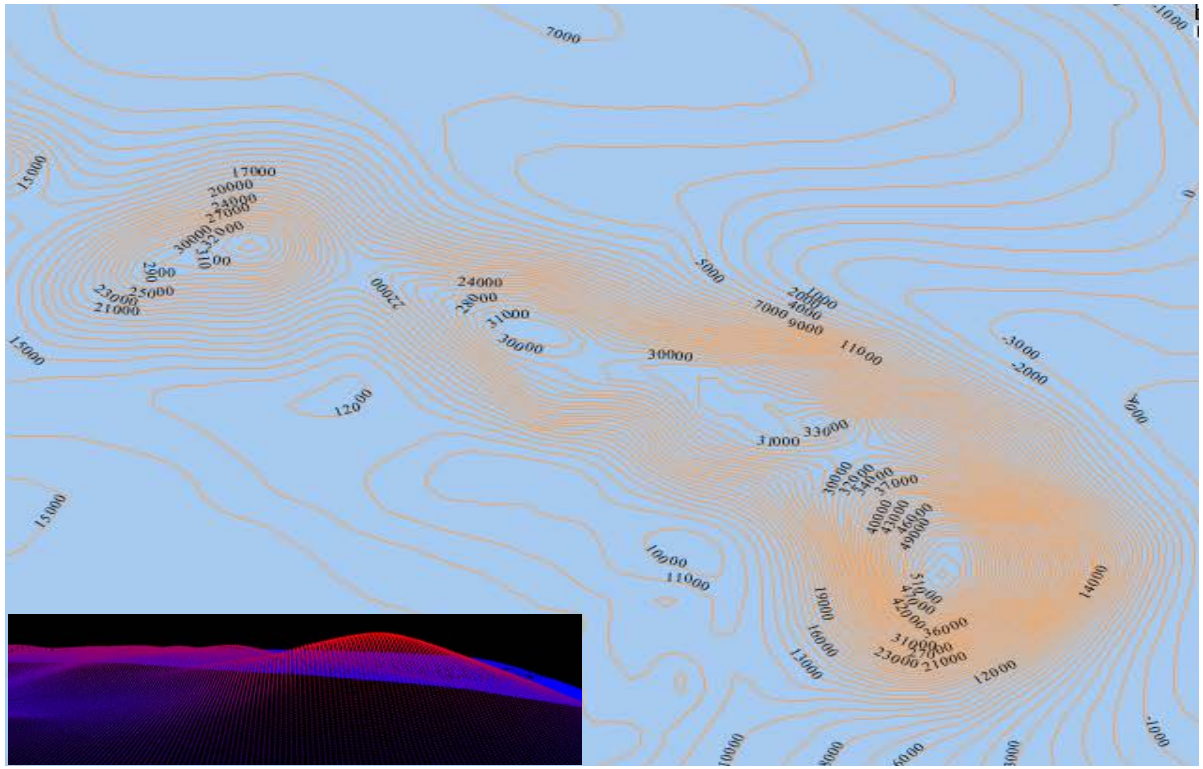
Schema based storage for Point Clouds

- XML schema based storage for SDO_PC data
  - This is similar to the metadata schema used for GeoRaster
  - First three fields should be doubles to store X,Y,Z
  - The optional fields can have one of the following data types
    - 8, 16, 32, and 64 bit signed and unsigned integer
    - Double, float
    - Strings can be stored as unsigned 8 bit integer (1 byte)
- Useful for publishing PC data for end user applications
- PDAL is an open source loading tool that supports SDO_PC

Other Enhancements for Point Cloud data

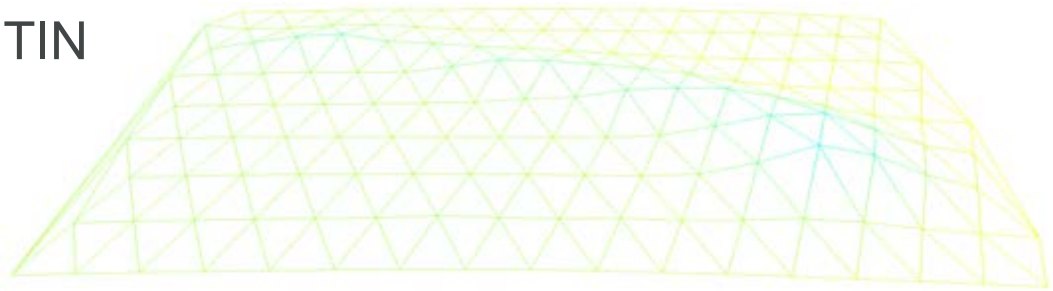
- Pyramiding support for PC and TIN data
  - PL/SQL API added to generate pyramids for existing point clouds
  - Points can be repeated in the pyramid levels or mutually exclusive
  - Useful for visualization applications
- Contour generation from PC data
  - Generate linear geometries that connect points with equal elevation values
  - A polygon can be specified to limit contour generation to a region
  - Contour generation process is grid-based in x and y
  - Krigging performed to assign heights to grids with no point data

Point-Cloud to Contour

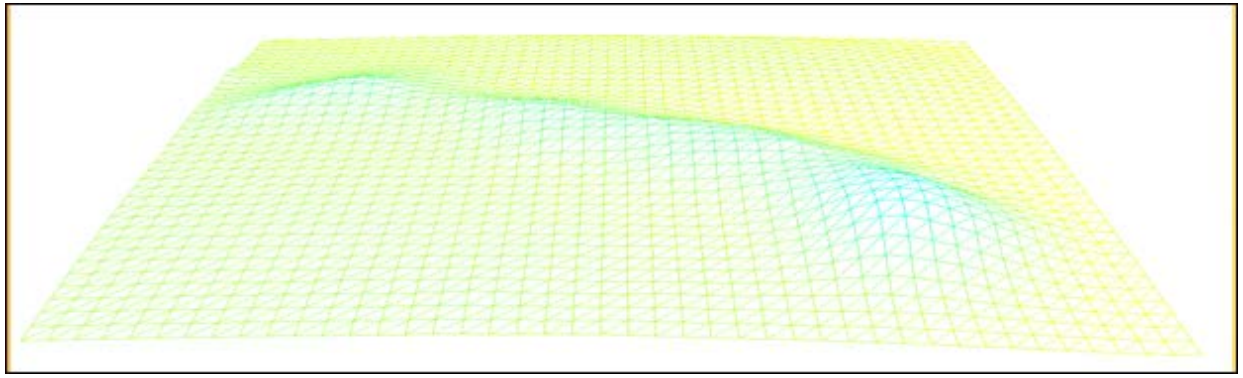


TIN To DEM

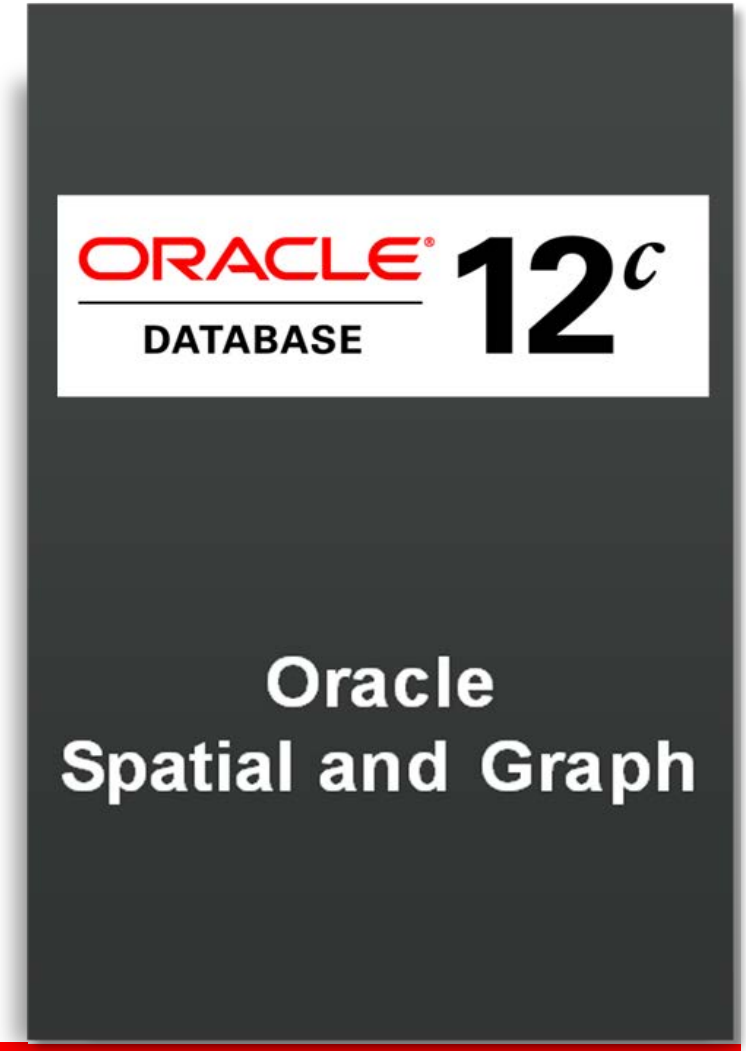
Input: TIN



Output: GeoRaster



GeoRaster



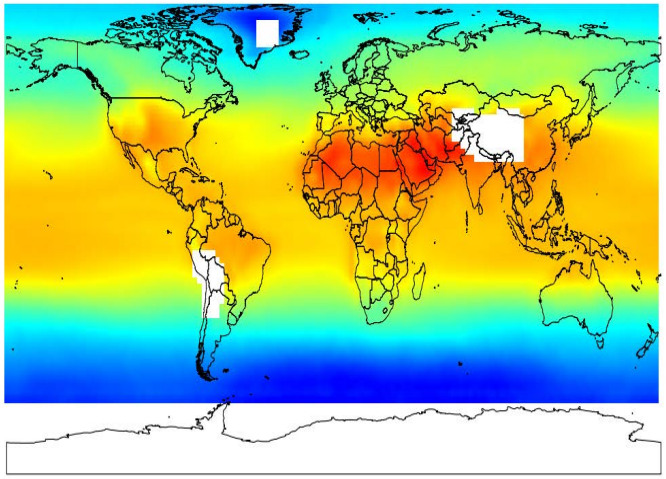
Raster Algebra

- **Raster Algebra (Map Algebra)** is a set-based algebra for manipulating geographic raster data
  - It is widely used for cartographic modeling and spatial analysis
- Includes a set of primitive algebraic operators applied on one or more raster layers of similar dimensions to produce one or more new raster layers or other values
- Provides a procedural or scripting language enabling very complex operations
  - Raster Algebra Language is provided as an extension to the PL/SQL
- Polygon clipping based statistics generation functions to support interactive analysis on-the-fly

Raster Algebra Example

Historical Temperature Analysis

- Temperature data stored as raster
  - Each pixel stores average temperature for 10X10 square meters for each month
  - Data collected for 33 years and for 12 months
- GeoRaster has 33X12 layers of data
- Find the average temperature for a given region of interest for the month of June



(Source Temperature Data Courtesy of Remote Sensing Systems - http://www.ssmi.com/)

Historical Temperature Analysis

- A collecion of 33 years of global temperature data for each month. In total, 396 layers stored in 1 georaster object:

1. The values are in Kelvin, which is converted to Fahrenheit
2. Generate the Average (mean) temperature for each month
3. Compute the Mean Absolute Deviation per Month (the mean difference from the average across 33 years for each month).

- use PL/SQL program to generate all expressions on the left and execute the rasterMathOp operations.

-- converting Kelvin to Fahrenheit

'({0}-273.15)*9/5+32'

-- compute average temperature for a month (January)

'({0}+{12}+{24}+{36}+{48}+{60}+{72}+{84}+{96}+{108}+{120}+{132}+{144}+{156}+{168}+{180}+{192}+{204}+{216}+{228}+{240}+{252}+{264}+{276}+{288}+{300}+{312}+{324}+{336}+{348}+{360}+{372}+{384})/33'

-- compute mean absolute deviation for a month (January)

'(abs({1,0}-{0,0})+abs({1,0}-{0,12})+abs({1,0}-{0,24})+abs({1,0}-{0,36})+abs({1,0}-{0,48})+abs({1,0}-{0,60})+abs({1,0}-{0,72})+abs({1,0}-{0,84})+abs({1,0}-{0,96})+abs({1,0}-{0,108})+abs({1,0}-{0,120})+abs({1,0}-{0,132})+abs({1,0}-{0,144})+abs({1,0}-{0,156})+abs({1,0}-{0,168})+abs({1,0}-{0,180})+abs({1,0}-{0,192})+abs({1,0}-{0,204})+abs({1,0}-{0,216})+abs({1,0}-{0,228})+abs({1,0}-{0,240})+abs({1,0}-{0,252})+abs({1,0}-{0,264})+abs({1,0}-{0,276})+abs({1,0}-{0,288})+abs({1,0}-{0,300})+abs({1,0}-{0,312})+abs({1,0}-{0,324})+abs({1,0}-{0,336})+abs({1,0}-{0,348})+abs({1,0}-{0,360})+abs({1,0}-{0,372})+abs({1,0}-{0,384}))/33'

Virtual Mosaic - An Advanced Image Query and Image Serving Engine

- A **virtual mosaic** is defined as any large collection of georeferenced GeoRaster objects (images) that is treated as if it is a single GeoRaster object (**physical mosaic**).
- Three ways to define a virtual mosaic:
  - a list of GeoRaster tables
  - a database view with a GeoRaster column
  - a SQL query statement (i.e., a CURSOR)
- A virtual mosaic can contain unlimited number of images of any size
- There is no need to define a description file for the virtual mosaic

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Virtual Mosaic - An Advanced Image Query and Image Serving Engine (Cont.)

- Virtual Mosaic queries support the same functionality as large-scale mosaicking:
  - Source images can be rectified or unrectified or in different CS
  - Support internal resampling, reprojection or rectification
  - Supports gaps, no data, and overlapping regions
  - Support 8 common point rules (max, min, avg, LATEST, OLDEST, etc...)
  - User defined priority for overlapping regions (Date or SQL ORDER BY)
  - Simple color balancing (linear stretch and normalization)

Sample Virtual Mosaic Use Cases

- DOQs can be stored as is but used as seamless mosaic (as fast as physical mosaics)
- Users may not want to mosaic DEM's
- Store large volume of imagery without making too many extra copies (save disk spaces)
- New images coming in can be displayed on the mosaic (dynamic updates)
- The same images can be displayed or removed in different virtual mosaics (flexible model)

New and Enhanced Tools and Java API

- **New Concurrent Batch Loading and Exporting Tool**
  - GUI to create GDAL-based batch loading and exporting description files (XML)
  - GUI to load batches of files concurrently
  - All GDAL supported file formats
- **GeoRaster viewer enhancement**
  - Display a virtual mosaic defined as one or a list of GeoRaster tables or views
  - Zoom-in, zoom-out and pan
- **GeoRaster Java API Enhancement**
  - Support for ground control point (GCP) storage and manipulation, GCP georeferencing, reprojection, grid interpolations, and getCellValue

Network Data Model

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Oracle
Spatial and Graph

Feature Modeling/Analysis

Model networks with application features

- Intuitive representation for applications
- Similar to Topology Data Model but not limited to geometry based features
  - Supports logical networks and physical networks in application representation
- Data model to manage node and link “features” with their associated “network elements” (Nodes/Links)
  - Node features: transformers, sub-stations, etc.
  - Link features: power lines, transit routes, etc.
- Consistency between network features and network elements automatically maintained
- Feature level analysis
  - Find the shortest path between two transformers
  - Find the shortest path between two transformers, but use only a certain wire type

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Temporal Modeling/Analysis

NDM Traffic Patterns

- Traffic Patterns
  - Traffic patterns record historical travel patterns for different classes of roads
  - Data is collected based on time of day and day of the week
  - Each road segment can have hundreds of travel patterns
- NDM can use this data while computing shortest paths
  - Analysis function APIs are extended with the concept of time
  - Find the shorted path from point A to point B with a start time of 9AM
  - Find the shortest path from point A to point B so that the destination is reached at 5.30PM
- Support NAVTEQ Traffic Patterns format out of the box

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Temporal Modeling/Analysis

Multi-Modal Routing

- Each mode (car, bus, rail, bike, etc) is modeled as a single network
- The multi-modal network is an aggregate of all selected modes
- A single logical network is used to represent all modes of transportation
- NDM APIs extended with the parameters to specify the mode type for path computations
- Out of the box support for transit data that is published by transit authorities
  - Support GTFS (General Transit Feed Spec)

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Enhanced NDM XML API

Web Service Enabled

- Provides a full fledged web services framework for network analysis
- Enhanced XML API with Network Constraint and Cost Calculator Support
- Integrated with Oracle Spatial and Graph Web Service Framework
- A Simple PL/SQL Wrapper (http put/get) on top of the XML API for Database Users
- A web service demo based on Oracle Spatial Web Service Framework is available in ndmdemo download kit
- New Driving Direction API
  - For NDM users with data in Routing Schema
  - Generate step by step driving directions format for final path

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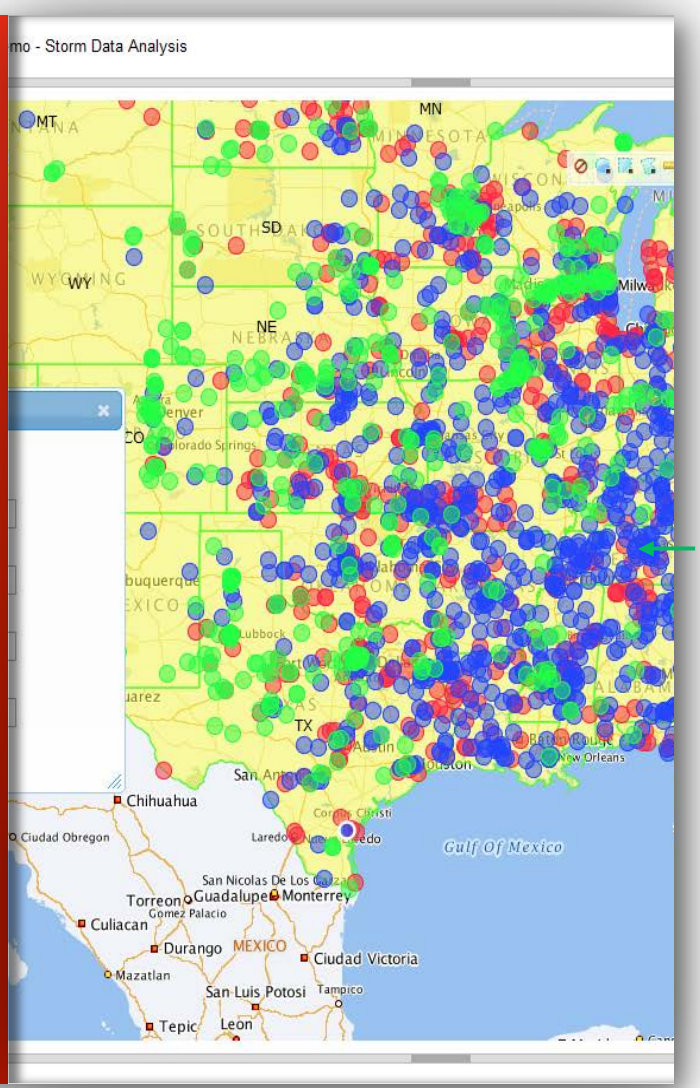
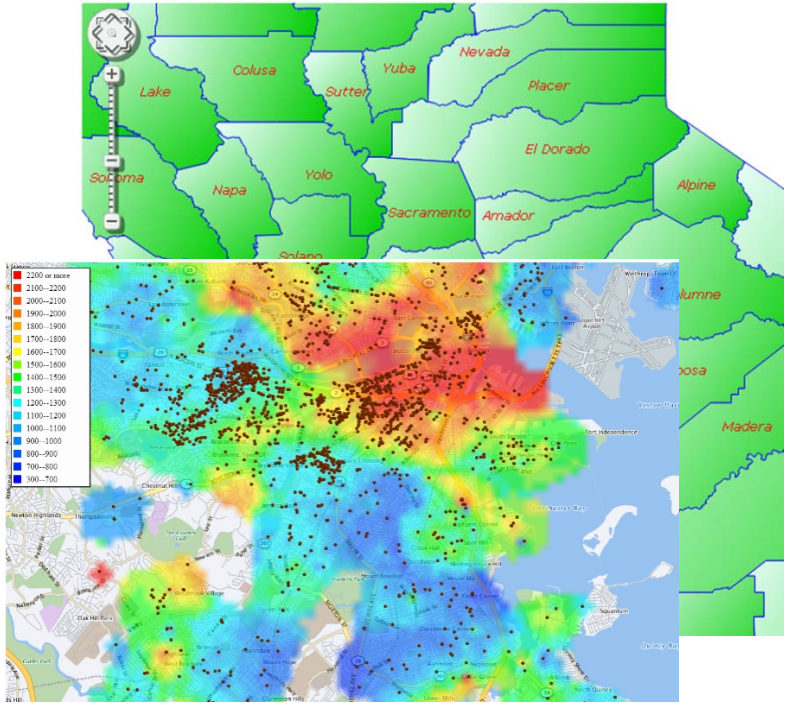
MapViewer New Features



HTML5 API

Overview

- Written from ground up
- Uses Canvas/SVG
- Browser renders JSON data with many effects and animations
- Supports all existing MapViewer metadata
- Natively supports Nokia, TomTom, Bing, OSM and other map services



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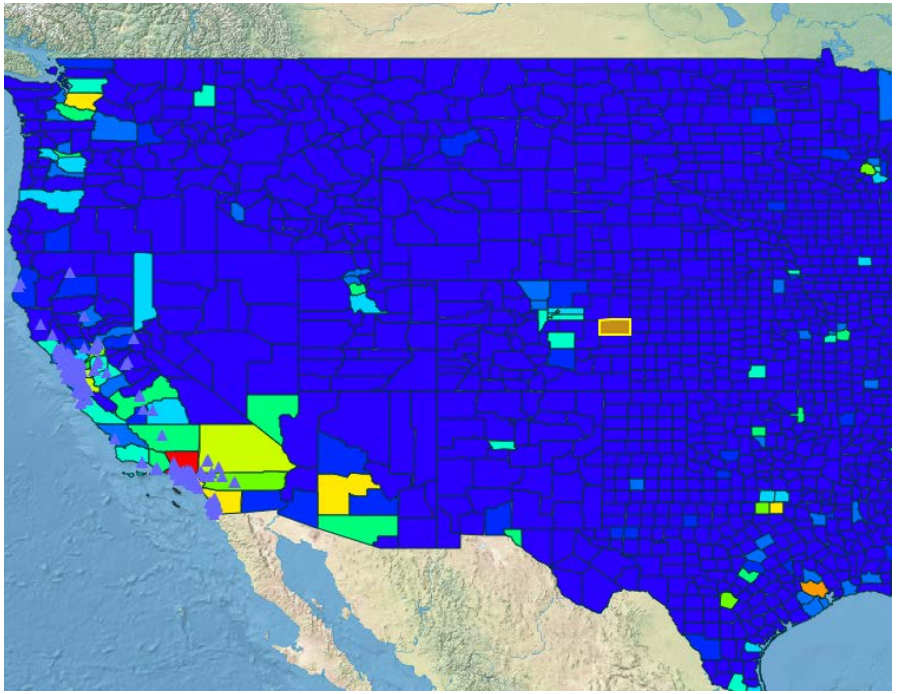
HTML5 API

Performance improvements in 11.1.1.7.1

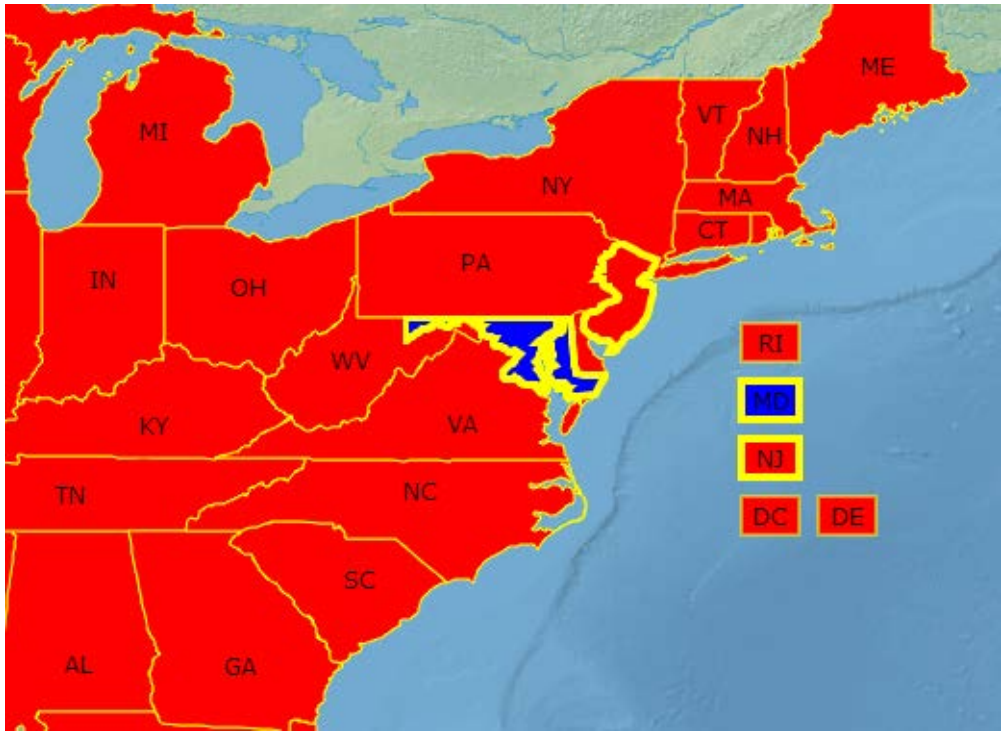
- Optimized canvas renderer
- Handles dirty area refreshes more efficiently
- Much better overall responsiveness with 10s of MBs of vector data



HTML5 API

Indicator features

- Introduced in 11.1.1.7.1
- Represents features too small to be labeled
- Fully automatic, configurable and interactive



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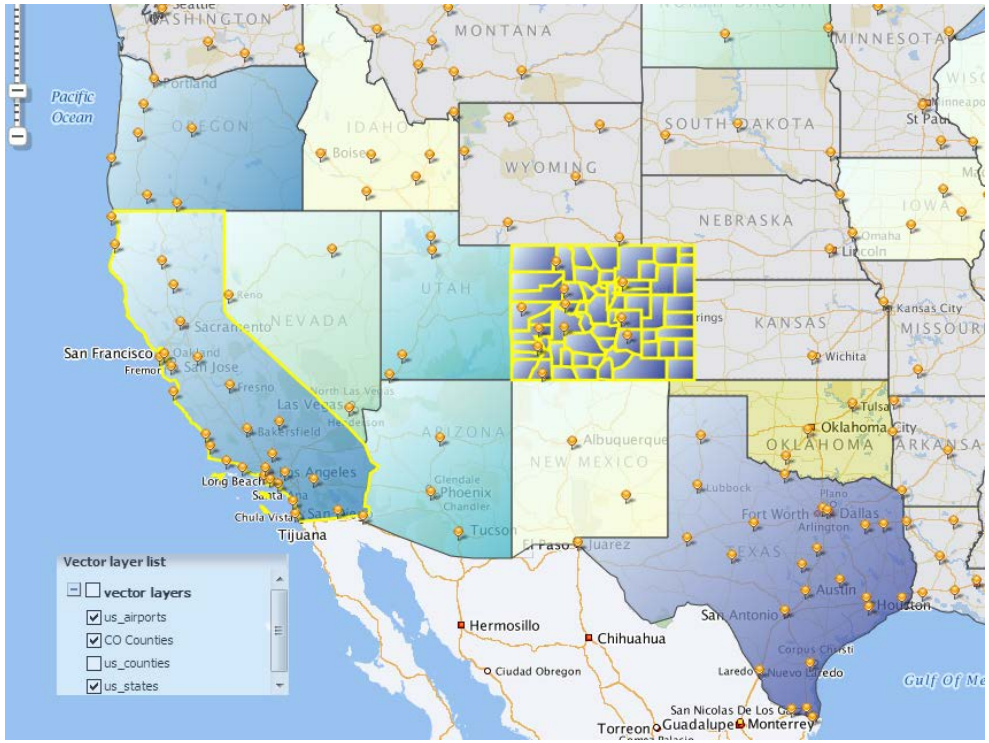
HTML5 API

Map Template

- Introduced in 11.1.1.7.1
- Set of related geoJSON files + a configuration file
- Config file lists metadata: layers, styles, initial map display et al
- geoJSON files generated by Map Data Server
- MapViewer server not required at run time

HTML5 API

A sample Map Template app



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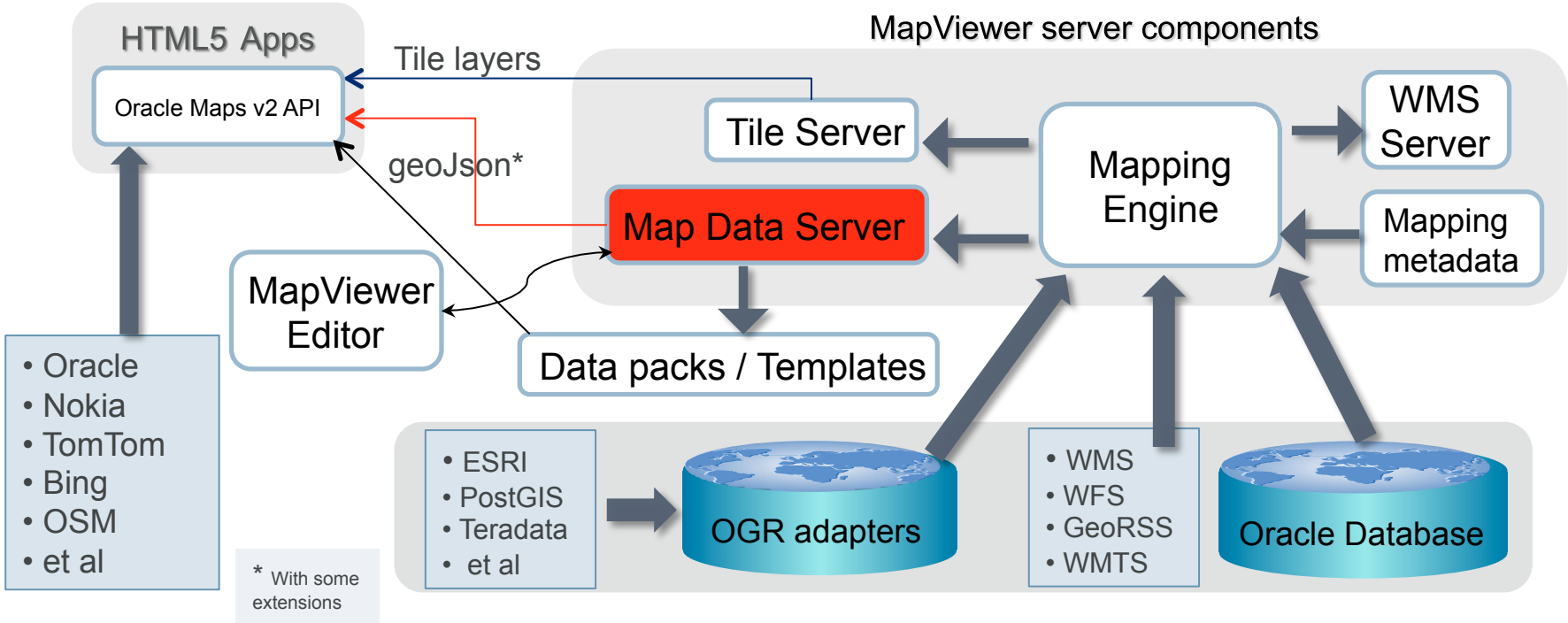
Map Data Server

A new component of MapViewer

- Streams predefined theme data to html5 clients
- Streams dynamic (JDBC) theme with ad hoc queries
- Streams geometry and session data to the Editor
- Spatial data transformed into geoJson format on the fly
- URL end point: */mapviewer/dataserver*

Map Data Server

A new component of MapViewer



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MapViewer Editor

Editing your spatial data on the web

- Runs as a Java applet
  - signed Jars
- Multi-user concurrent editing
  - Supports conflict resolution
- Supports Workspace Manager and versioning
- Edits WFS-T data
- Provides geometry validation and simplification tools

Ordnance Survey Ireland

More Information …

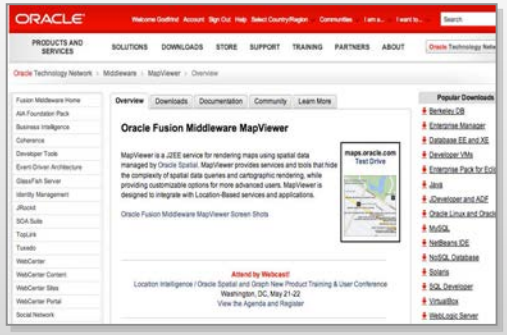
http://www.oracle.com/technetwork/middleware/mapviewer

Resources

- **Oracle Technology Network**

  Get software downloads, sample code, tech info, updates, documentation, partner resources

  - **Oracle Spatial and Graph**
    www.oracle.com/technetwork/database-options/spatialandgraph/overview/spatialfeatures-1902020.html
  - **Oracle Fusion Middleware MapViewer**
    www.oracle.com/technetwork/middleware/mapviewer/



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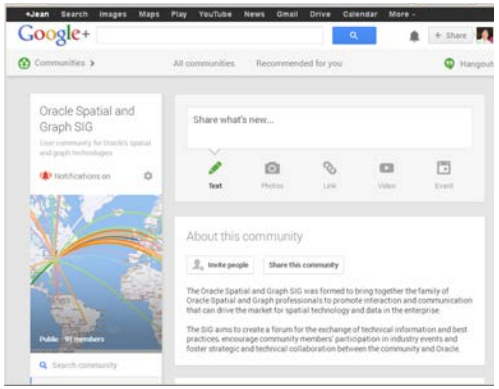
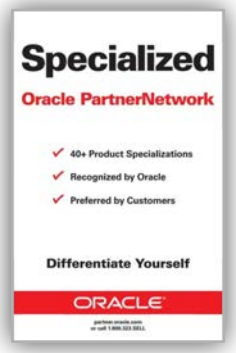
User Groups & Certification

- **Oracle Spatial & Graph Special Interest Group:**
  Connect and exchange knowledge with the user community
  - ***Meet the SIG Board at OOW: Wed 9/25, 2:00-3:00pm OTN Lounge, Moscone South Lobby***
  - Join our groups: LinkedIn, Google+, IOUG SIG
  - Visit **OTN Spatial – Community**
    Search online for **"Oracle Spatial and Graph Community"**
  - Email **oraclespatialsig@gmail.com**



- **Individual Certification, Partner Specialization**
  - www.oracle.com/technetwork/database-options/spatialandgraph/learnmore/spatial-partners-423197.html
  - Talk to Oracle team this week at OPN Lounge or Oracle Spatial & Graph demopod in Moscone South



Spatial and Graph at OOW 2013 - Sessions

Date/Time	Title	Location
Monday, Sept 23		
1:45 PM - 2:45 PM	Best Development Practices with Maps, Spatial, and Graph Analytics	Marriott Marquis - Golden Gate C2
3:15 PM - 4:15 PM	Latest Spatial Features in Oracle Database 12c	Moscone South - 303
4:45 PM - 5:45 PM	Fast Data with Oracle Event Processing	Moscone North - 130
4:45 PM - 5:45 PM	Newest Graph Features in Oracle Database 12c	Moscone South - 303
7:15 PM - 8:00 PM	What's New in Location Analytics: HTML5, Mobile, and Spatial in Oracle Database 12c **[Birds of a Feather]**	Marriott Marquis - Foothill G
Tuesday, Sept 24		
12:00 PM - 1:00 PM	Enhancing City Public Transportation	St. Francis - Elizabethan C/D
Wednesday, Sept 25		
11:45 AM -12:45 PM	Customer Experiences with Oracle Spatial and Graph	Moscone South - 300

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Spatial and Graph at OOW 2013 – Demos

Date/Time	Title	Location
Monday - Wednesday	Oracle's Spatial Technologies	Moscone South Exhibition Hall Oracle Database DEMOgrounds (Left - SL-070)
Monday - Wednesday	Graph Database for the Enterprise	Moscone South Exhibition Hall Oracle Database DEMOgrounds (Left - SL-069)
Mon, 12:00-12:20pm Wed, 10:30-10:50am	Location-Based Services (Big Data Theater)	Moscone South Exhibition Hall Room 106 - Industry Showcase Theater

Partners

Date/Time	Title	Location
Monday - Wednesday	HERE, a Nokia Business	Moscone South Exhibition Hall Booth #2232
Monday - Wednesday	Esri	Moscone South Exhibition Hall Booth #640

ORACLE

Spatial and Graph at OOW 2013 – Hands On Lab

Date/Time	Title	Location
Tuesday, Sept 24		
10:30 AM - 11:30 AM	Fast Data Best Practices and Design Patterns with Oracle Event Processing	Marriott Marquis - Salon 12/13

Meet-Ups

Date/Time	Title	Location
Wednesday, Sept 25		
2:00 PM - 3:00 PM	Oracle Spatial and Graph Special Interest Group Meet-Up	OTN Lounge - Moscone South Lobby
2:00 PM - 3:00 PM	RDF Graph User Meet-Up with Oracle Product Team	OTN Lounge - Moscone South Lobby