

Oracle10g & Beyond



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What is spatial data?

- **Spatial data is ubiquitous**
- Business data that contains or describes location
 - Street and postal address (customers, stores, factory, etc.)
 - Sales data (sales territory, customer registration, etc.)
 - Assets (cell tower, fire hydrant, electrical transformer, etc.)
 - Geographic features (roads, rivers, parks, etc.)
- Anything connected to a physical location
- Every database in the world contains some form of business data that can be leveraged using spatial technologies

What Business Problems Are Solved using spatial software?

- Problems relating to customers, market and site location can all be solved by leveraging spatial technologies

Where are my customers or constituents?

How much is this insurance really going to cost me?!

- What are the environmental, economic and health effects of logging, building, drilling in a certain area?
- What percentage of customers account for store sales and where are they located?
- What are the demographics in my most successful sales territories?
- Can I consolidate sites without hurting customer service?

Bringing it all together

Information Type

Location-enabled Use

- Address



- Map Customers and Business Relationships

- Routes, Utility, infrastructure, etc.



- Develop Routes / Trace & Manage Field Assets and Parcels

- Administrative areas (zip, tax, county, area code, real estate, sales territories etc.)



- Summarize, Compare, Drill Down Analytics, Track Assets etc.

Location in the Oracle Database

Relational and GIS Data in a Hybrid setup

NO Data Integration

“Give me all you know about roads in San Francisco...”

Road

ROAD_ID	NAME	SURFACE	LANES
1	Homestead	Asphalt	4
2	Bellomy	Asphalt	2
3	Santa Clara	Asphalt	2

GIS



Spatial Data in Oracle Tables



Road

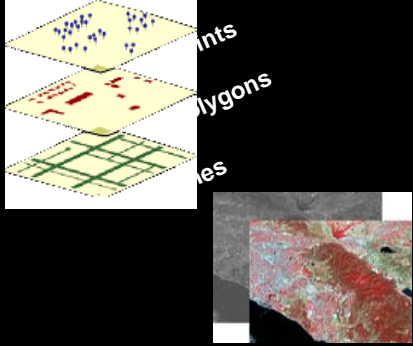
Data Types and Models:

Vector [SDO_GEOMETRY
SDO_TOPO_GEOMETRY
Raster | SDO_GEORASTER

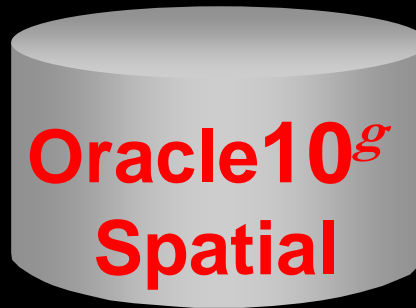
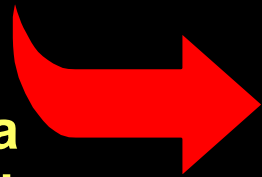
ROAD_ID	NAME	SURFACE	LANES	LOCATION
1	Homestead	Asphalt	4	
2	Bellomy	Asphalt	2	
3	Santa Clara	Asphalt	2	

Oracle10^g Core Spatial Capabilities

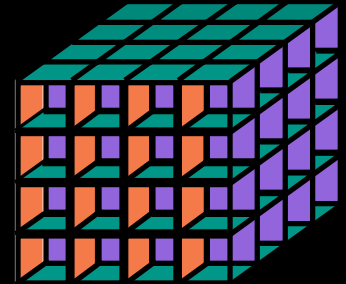
Spatial Data Types



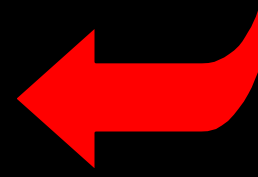
All Spatial Data
Stored in the Database



Spatial Indexing



Fast Access to
Spatial Data



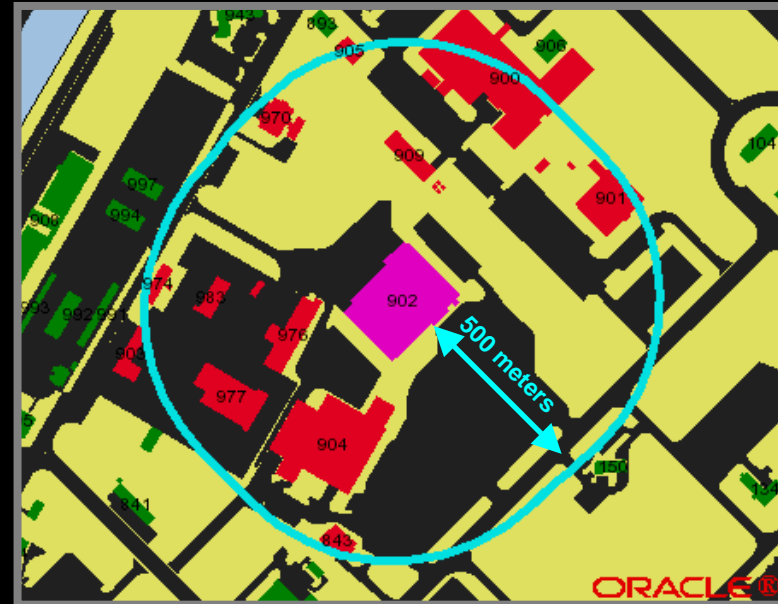
Spatial Access Through SQL

```
Select a.building_id  
  from facility a, facility b  
 where sdo_within_distance( a.geom, b.geom  
                           'distance = 10 unit = mile') = 'TRUE';
```


Spatial Query Via SQL

Find all buildings within 500 meters of building 902

```
SQL> SELECT a.building_id
2>    FROM base_buildings a,
3>         base_buildings b
4>   WHERE b.building_id = 902
5>         AND SDO_WITHIN_DISTANCE(
6>             a.Location, b.Location,
7>             'distance=500') = 'TRUE';
```



Oracle: Defining the Spatial DBMS

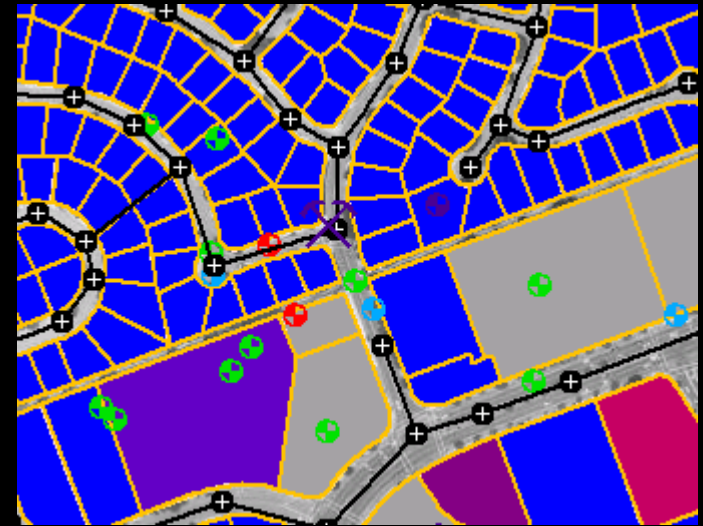
- SQL Spatial Type
- R-tree index
- Spatial Operators
- Spatial Reference System
- Geodetic (lat/long) Support
- Whole Earth Model
- Linear Referencing
- Spatial Aggregates
- Long Transactions
- Parallel Index, Query, Load
- Partitioning
- GeoRaster Type
- Network Data Model
- Topology Data Model
- Geocoding Engine
- Routing Engine
- Spatial Data Analysis / Mining
- GML 2.0 and 3.0
- SVG Support
- Oriented Point / Text Geometry

Oracle10g Database Spatial Features

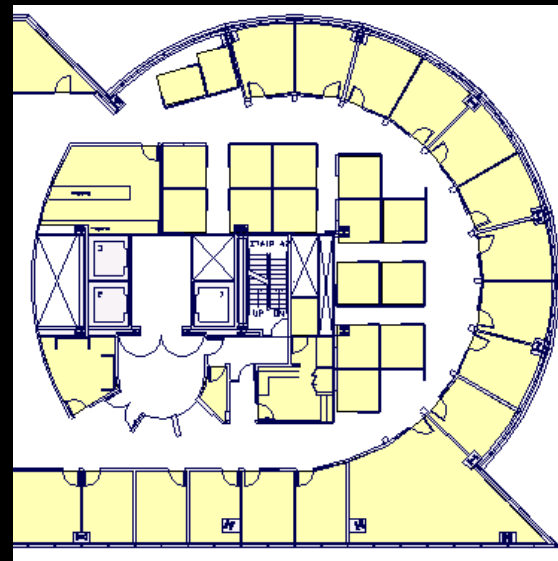
SDO_GEOMETRY

Vector Data Types

- Points
- Line Strings
- Polygons
- Polygons with holes
- Circles
- Arcs, arc strings
- Rectangles
- Compound elements



Geographic Data



Non-Geographic Data

Geocoder & Routing

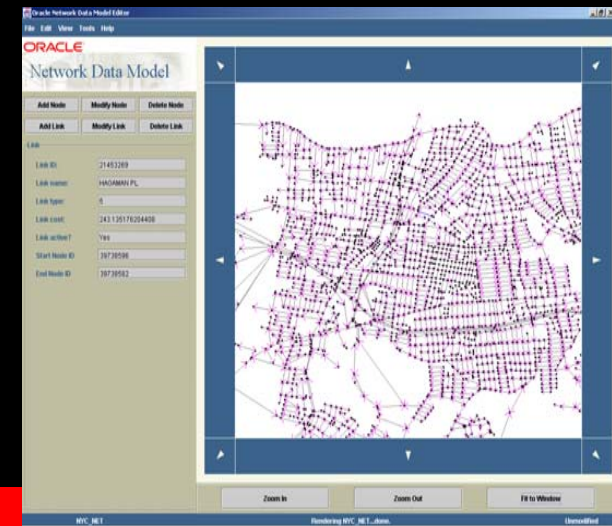
- Geocoding Engine within the Oracle database
 - Generates latitude/longitude (points) from address
 - Supports international addressing standardization
 - Data dictionary completely extensible
- Router Data within the Oracle Database
 - Standard directions output as XML
- Base dictionary data available from Navteq & TeleAtlas

Northport
680 Fort Salonga Rd
Huntington, NY 11768

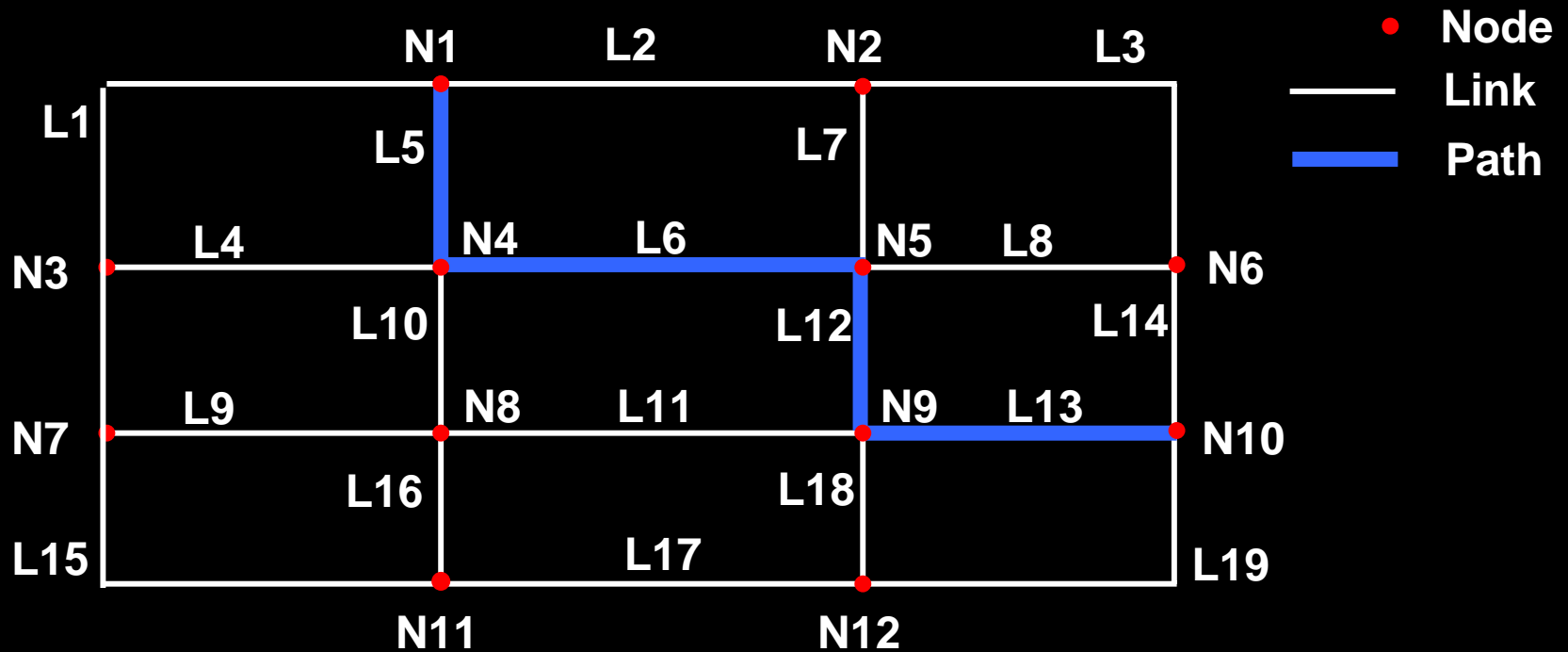


Network Data Model

- **Network Data Model**
 - A data model to store network (graph) structure in the database
 - Explicitly stores and maintains connectivity of the network
 - Attributes at link and node level
- **Routing Engine**
 - Street navigation for single or multiple destinations
 - Provide network analysis functionality in the database
- **Supports Network solutions (Tracing & Routing)**
 - Transportation and Transit Solutions
 - Field Service, Logistics
 - Location based Services, Telematics
- **Bio-Info Pathways (Life Sciences)**
 - Hierarchical Networks
 - Scale-free Networks
 - Small Worlds



What is a network?



Spatial Analysis Versus Network Analysis

Spatial analysis:

- Accomplished with traditional Oracle Spatial
- Connectivity not required for proximity and distance
- Maintains topological relationships

Network analysis:

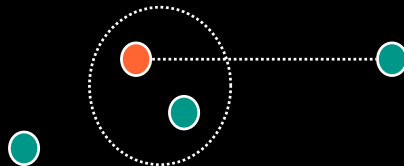
- Connectivity:
 - Solely based on cost and direction of links (graph analysis)
 - Uses link/node cost and link direction

Spatial proximity

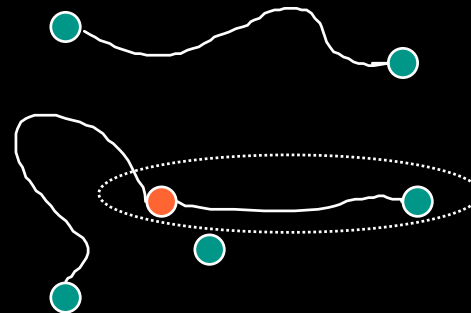
Distance



Closest feature



Connectivity



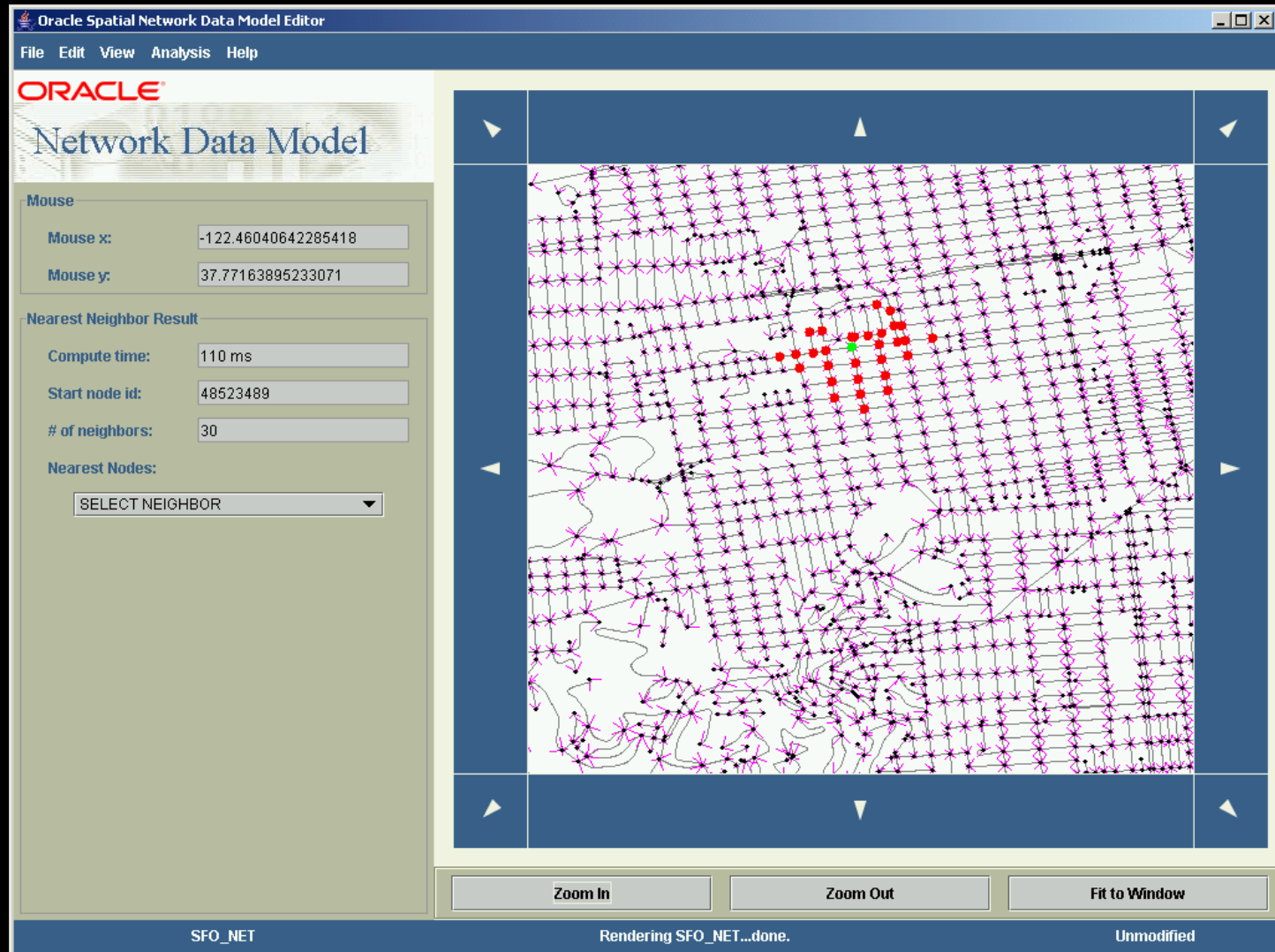
Oracle Network Data Model

- Analysis is based on **connectivity** and optionally **cost** information
- Common analysis includes:
 - **Accessibility** (start at node X, can node Y be accessed)
 - **Least cost path analysis** (cheapest path from X to Y)
 - **Within cost analysis** (given a cost limit and a start node, what nodes can be reached)
 - **Minimum cost spanning tree** (the least expensive way to connect all nodes in a network)
 - **Traveling Salesman Problem**
 - **All paths between nodes**
- Many other analysis functions
- Result of analysis is often a path
 - A path has start and end nodes, and one or more links

Benefits of Oracle's NDM

- Provides an open and generic network data model for network applications
 - Network data model information is stored in tables in the database
 - SQL queries can be issued
- Allows the extension of data model and analysis capabilities
- Enables spatial information support
 - Spatial information can be associated with the network using the Oracle Spatial format

Network Data Model Editor



Topology Data Model

- New data model to store ***persistent*** topology
 - Easier to do data consistency checks in this model
 - Example: when the road moves, the property boundary automatically moves with it
- Topology Data Model and Schema
 - Describes how different spatial features are related to each other
 - A land parcel shares the boundary with a road
- 10g continues to support transient topology
 - Topology computed on demand
 - Customers have choice of 2 topology management capabilities



Oracle Spatial Vector Data Models

- Each of these represents a spatial feature.
- Oracle Spatial can store features in two ways:
 - Object storage: Each feature is stored as a separate, complete object.
 - Topology storage: Each feature is modeled in terms of the topological primitives it is composed of.

California



Main Street

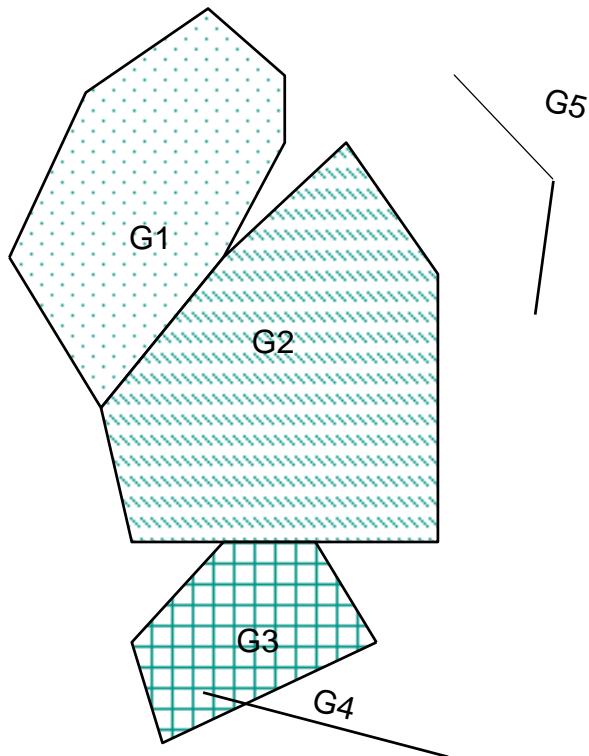


Current car
location

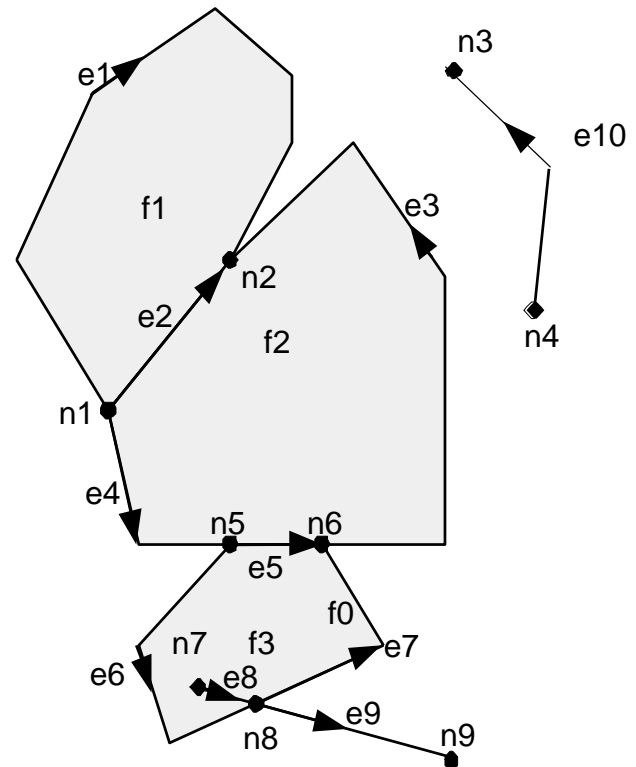


Oracle Spatial Vector Data Models

Object View

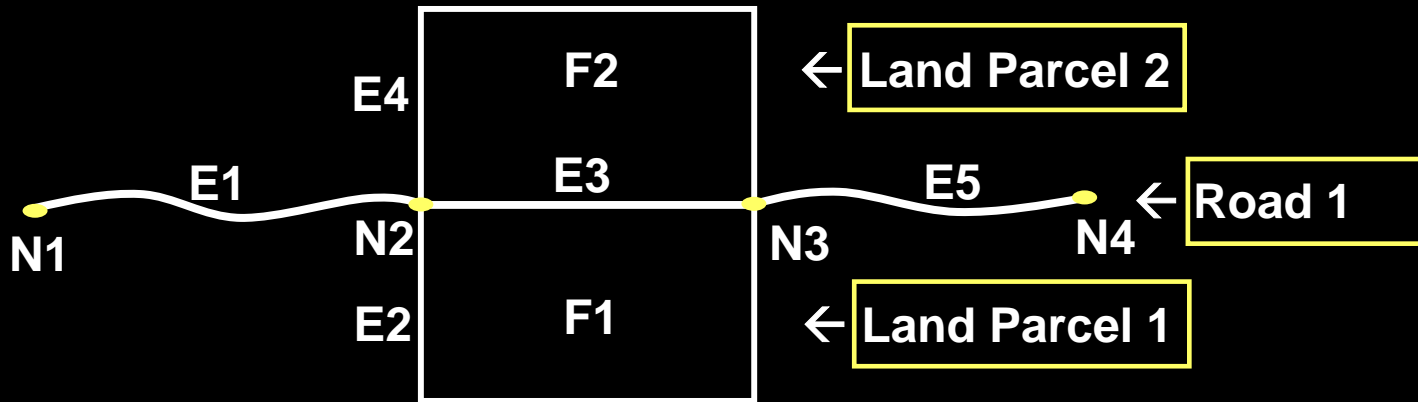


Topology View



Topology Example

- Land parcel features
 - Land Parcel 1 associated with face F1
 - Land Parcel 2 associated with face F2
 - Both faces include edge E3.
- Road features
 - Road 1 associated with edge E3 (and edges E1 and E5)



Hierarchical Feature Model: Example

- Parcels features derived from topological primitives (faces)
 - Oracle table called **PARCELS** with **SDO_TOPO_GEOMETRY** column
 - Each parcel feature is derived from topological primitives (faces)
- Neighborhoods features derived from parcels features
 - Oracle table called **NEIGHBORHOODS** with **SDO_TOPO_GEOMETRY** column
 - Each neighborhood is derived from a list of parcel features
- School District features derived from neighborhood features
 - Oracle table called **SCHOOL_DISTRICTS** with **SDO_TOPO_GEOMETRY** column
 - Each school district feature is derived from a list of neighborhood features

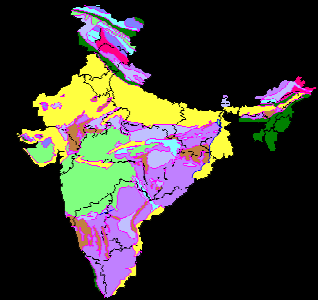
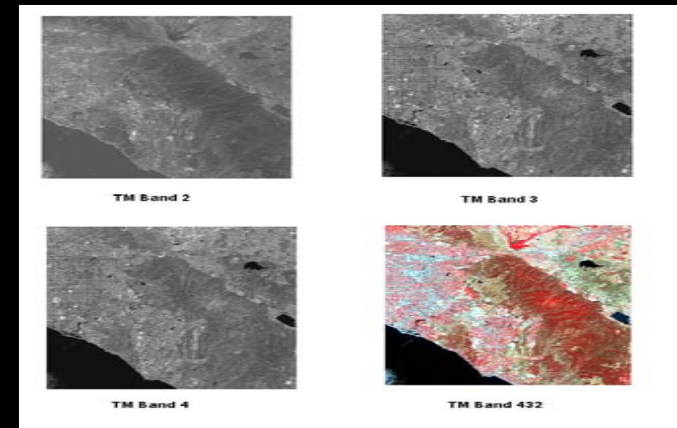
Advantages of Using Topology

- Some of the advantages of using topology to store and manage data include the following:
 - No redundant storage of data
 - Shared edges between objects are stored only once.
 - Features from *different* columns can share edges, such as roads and land parcels.
 - Persistent Data consistency
 - There are no “registration” issues between geometries.
 - Moving a boundary between objects is done once.
 - Quick and easy determination of topological relationships

SDO_GEORASTER

GeoRaster Data Support

- Some of the types of data supported by GeoRaster, classified by Data source:
 - Satellite imagery
 - Airborne photographs
 - Thematic grid maps
 - Digital terrain/elevation models
 - Lattice GIS data
 - Scanned maps and graphs
 - Raster data associated with geology, geophysics, and geochemistry
 - Medical images
 - Others



What is GeoRaster?

A new data type to store raster data

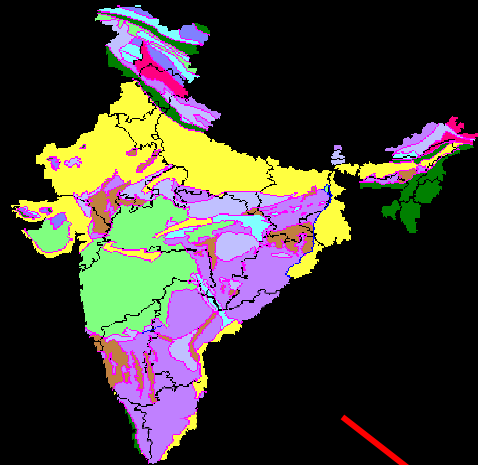
- Satellite images, remote sensing data, grids
 - Multi-band, multi-layer
- An XML schema to store Metadata
 - Data source, layer information
- Geo Referencing information
 - Relates image pixels to a longitude/latitude on Earth's surface

Operations on the new data type

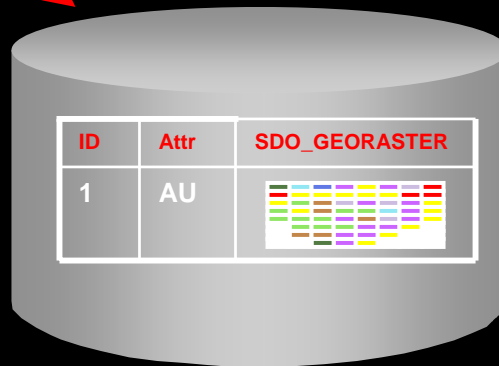
- Storage and indexing of raster data
 - Logical / physical storage separation
 - No size limit for raster objects
- Generate resolution pyramid
- Query and analysis
- Importing and exporting



Geological Map of India

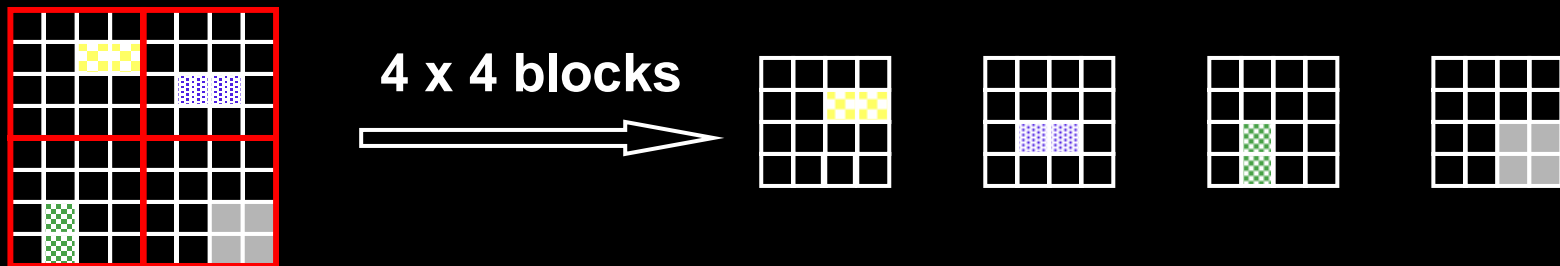


- Quaternary
- Tertiary
- Paleocene-Cretaceous
- Mesozoic
- Gondwana
- Early Palaeozoic
- Late Proterozoic
- Early Proterozoic
- Archaean



Blocking

- A GeoRaster image can be composed of an extremely large number of cells
- It is more efficient in terms of storage and retrieval to break large images into smaller blocks
- In GeoRaster, users/applications can determine how data is blocked
 - Specify rows, columns, and optionally bands

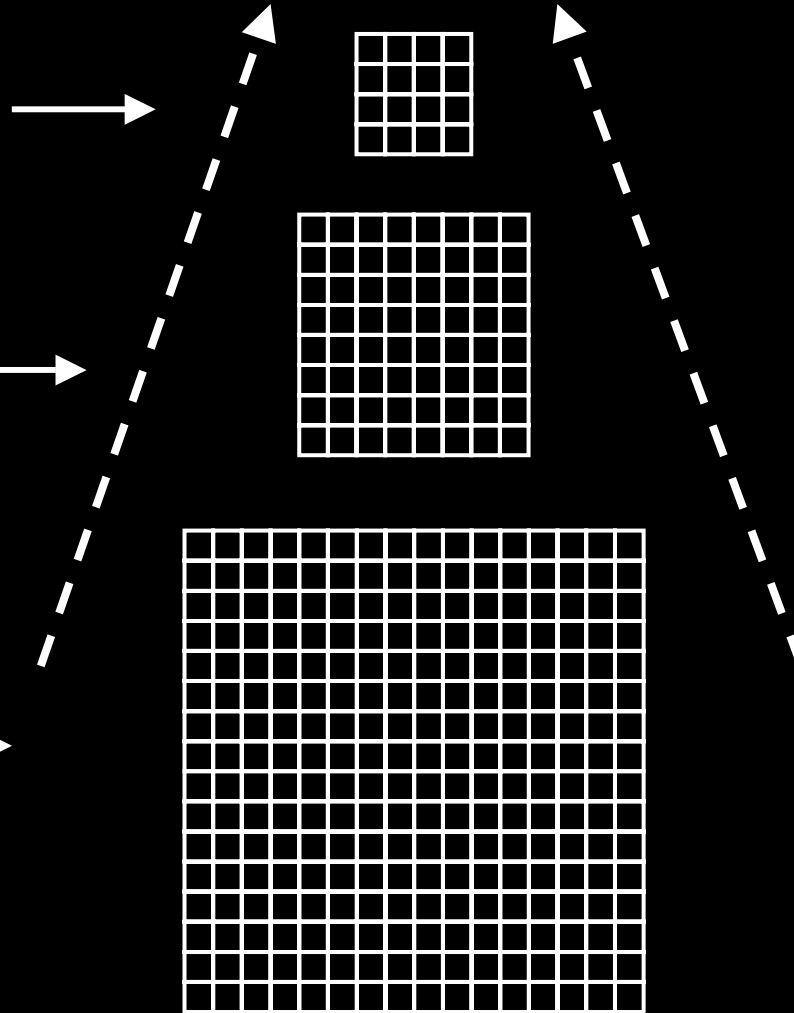


Resolution Pyramid

**Pyramid
Level 2
(4x4 cells)**

**Pyramid
Level 1
(8x8 cells)**

**Pyramid
Level 0
(16x16 cells)**



GeoRaster Functions

- Insert, update, index, and retrieve raster data and metadata
- Raster Manipulation:
 - Generate pyramids
 - Copy
 - Change format: Interleaving, blocking
 - Subset: Clip GeoRaster data by band or layer
 - Scaling: Enlarge or reduce
 - Generate the spatial extent of an image
 - Tile adjacent images to build a mosaic of the data
- Georectified and georeferenced GeoRaster data is supported

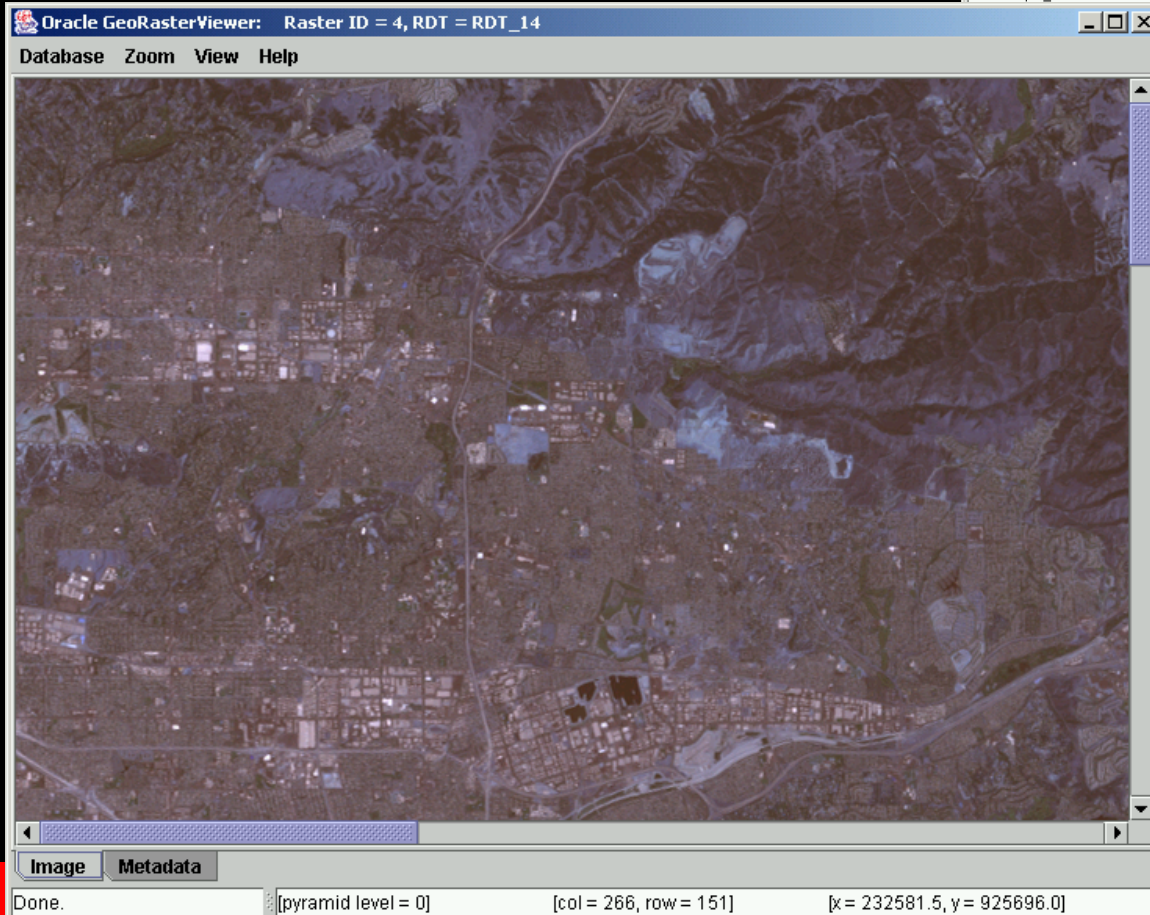
GeoRaster Functions

- Oracle relies on partners to import/export data many data formats to/from the SDO_GEORASTER data type
- Oracle's minimum support for loaders and exporters include:
 - TIFF/GeoTIFF
 - ESRI World File
 - JPEG
 - GIF
 - BMP
 - PNG
- MapViewer provides simple support for visualization of GeoRaster data

Advantages of using GeoRaster

- Database management of raster data
 - No size limit for raster objects
 - Very efficient reading and writing of large raster data sets
- Generate resolution pyramids, blocking and formats on the fly
- Query and analysis using standard methods (SQL, APIs, tools)
- Importing and exporting to different formats

Raster Viewer



Oracle GeoRasterViewer: Raster ID = 4, RDT = RDT_14

Database Zoom View Help

Attribute	Value
objectInfo	
rasterType	21001
isBlank	false
defaultRed	1
defaultGreen	2
defaultBlue	3
rasterInfo	
cellDepth	8
cellDepth_text	8BIT_U
	3
	2000
	2000
	8
	0
	0
	0
	REGULAR
	250
	1
	1
	8
	2000
	8
	BIP
	DECREASE

pyramid level = 0] [col = 155, row = 472] [x = 229418.0, y = 916547.5]

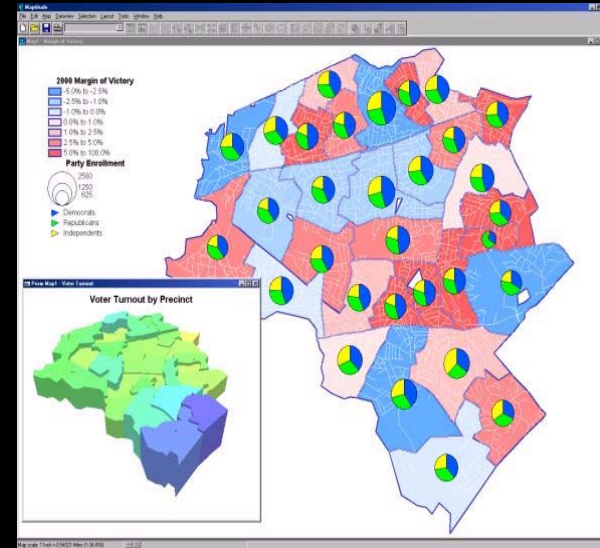
Spatial Analytic Functions

- **Discovery based on Spatial Patterns**

- Explicitly materialize spatial relationships

- **Usage**

- Insurance risk analysis, crime analysis
- Demographic analysis, customer profiling
- Epidemiology, Facility placement
- Insurance Risk analysis:
 - cluster house-holds based on high risk neighborhoods
- Identify business prospects across a region:
 - examine the average incomes across different regions of the space



What is spatial analysis?

Correlate data based on location (spatial correlation).

- ***Neighborhood analysis***
 - Determine specific information about an area of interest
 - Proportion of theme layer geometries overlapping geometry of interest is applied to aggregate analysis
- ***Spatial binning***
 - Classify data based on location
- ***Spatial clustering***
 - Determine patterns based on location
- ***Co-location analysis***
 - Determine how the location of one thing correlates to the location of something else

Customers Reaping Immediate Benefits Across the Board

- **US Census Bureau Redesigning Tiger/MAF**
 - Utilizing Topology Model in Oracle10g Spatial
 - Reshaping business processes and validations for future topology models
- **Cerebra utilizes Network Analysis in Resource Description Framework (RDF)**
 - Dramatically improving the way vocabulary, data, process, policy, and Web services interoperability are accomplished.
- **US EPA Utilizes Analytics and Georaster**
 - New processes for analysts to evaluate contaminations and come up with solutions based on dynamic data (imagery and vectors)

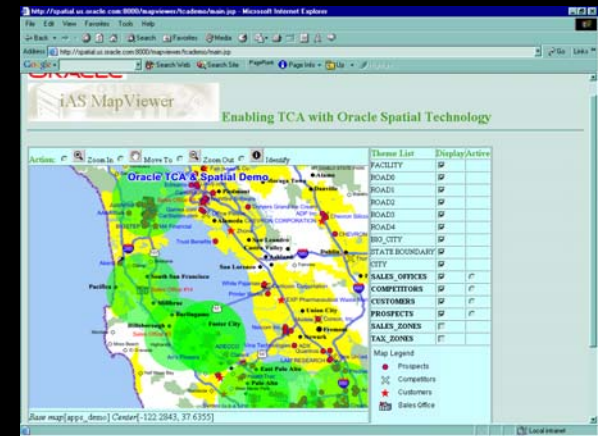
Long term Benefits

- Integrated enterprise data management for continually growing datasets
 - Spatial and non-spatial in nature
- Consolidated management of spatial operations
- Greater security and interoperability
- Enhanced decision support and business intelligence
- Service Oriented Architecture based on integrated data model
- Reduced training requirements
- Spatially enabled applications

Oracle Application Server 10g MapViewer and LBS Features

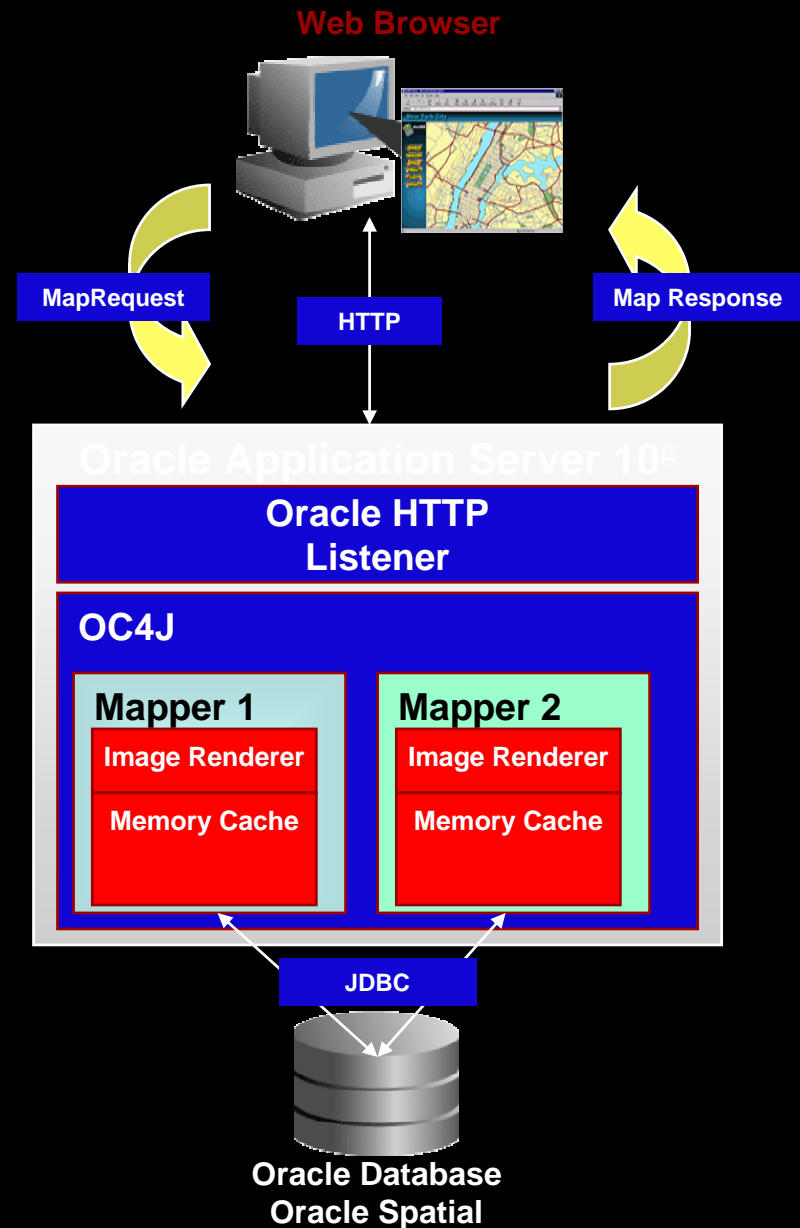
Oracle Application Server 10^g MapViewer

- No cost feature of the Oracle Application Server
- Supports vector and raster data
- Easily publishes spatial data to the web
- Centralized managed symbology, annotation and map definition rules
- Provides an XML API, Java API, JSP Tag library and OGC WMS interface



MapViewer Characteristics

- Scalable. Stateless.
- Makes use of JDBC connection pooling and caching
- Caches Mapping Metadata (basemap/theme/style definitions)
- Caches geometric and image data in the mid-tier.
- All data queried from Oracle database



MapView: Map

- Renders from spatial data stored in Oracle database
- Defined as a collection of themes
- May contain a legend, title and footnote
- Users request maps using via a MapRequest
- MapViewer returns a map via a MapResponse

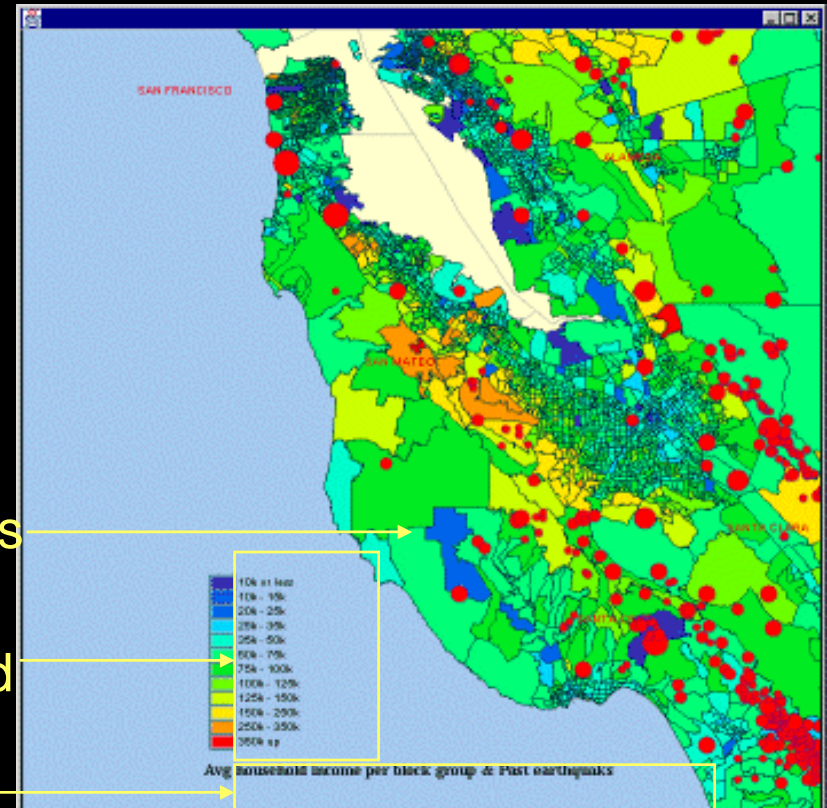
Title

Earthquakes

Themes

Legend

Footnote



MapView: Layer Vectors and Rasters

- Render data from vectors and rasters on the fly
- Use SVGs to dynamically render movement etc.



OracleAS 10g Location Based Services

- **Java APIs** - ingest online web services: geocoding, routing, mapping, YP, traffic, mobile positioning
- **Region Modeling** - associates services (billing, personalization) by (geographic) “regions”
- **Location Caching** - caches caller’s phone number & location to minimize wireless network pinging.
- **Location Privacy** - manages based on LBS service type, permissions, and subscription.
- **Location Marks** - Manages user defined locations of interest (home, work, PIM addresses)

What's Next?

Feature overview

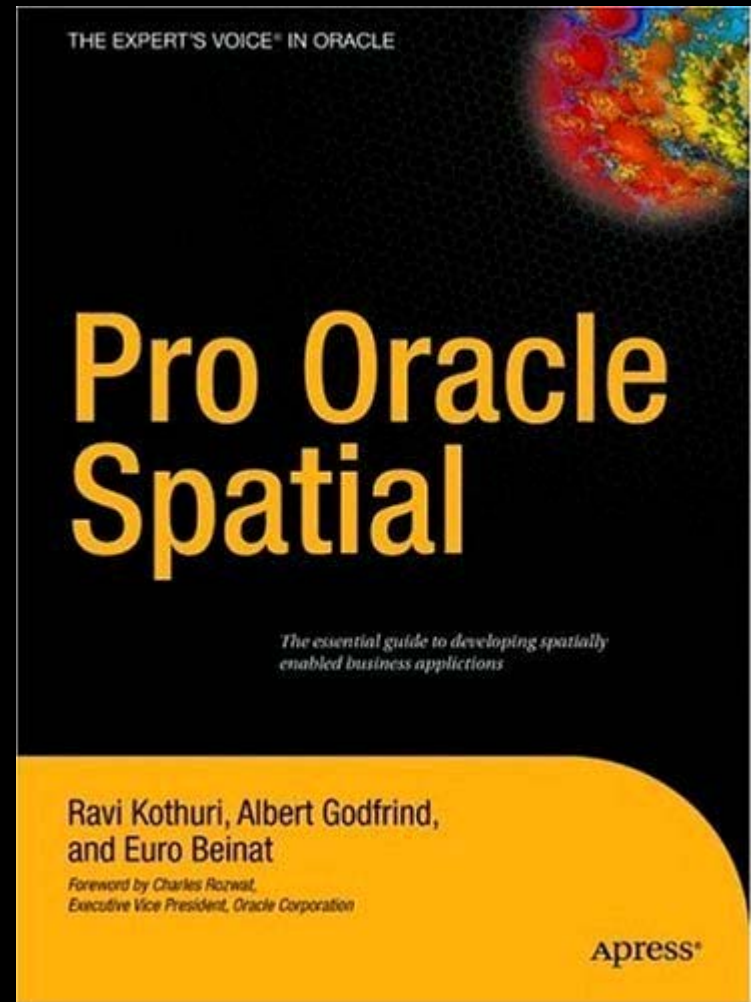
- Feature enhancements
 - GeoRaster enhancements
 - Network Data Model enhancements
 - Topology model enhancements
 - Geocoder and Router enhancements
- 3D Support
 - Types and functions
- Spatial in Business Intelligence
- MapViewer updates

Summary

- Location information is as ubiquitous as attribute and scalar information
 - Oracle Locator, Spatial and MapViewer location-enable the entire enterprise
 - New models to support changing needs and analysis
- Most comprehensive integration with partner tools in GIS and LBS
- And it just keeps going...

More Information & Resources

- Oracle Technology Network
 - <http://www.oracle.com/technology/products/spatial/index.html>
- Oracle.com
 - http://www.oracle.com/database/cm_spatial_new.html
- *New Book: Pro Oracle Spatial





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