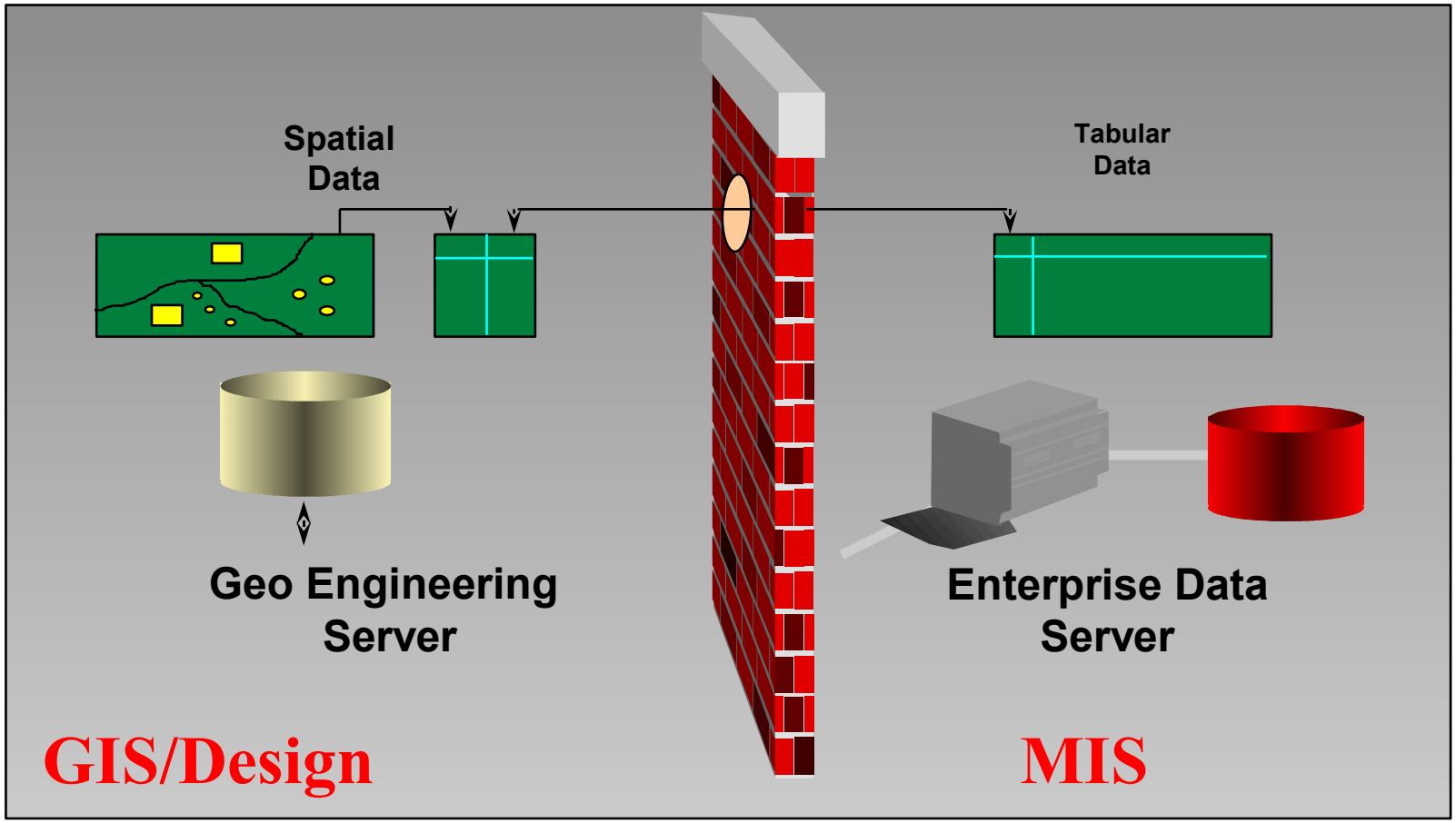
Oracle's Spatial Technologies (In a Nutshell)

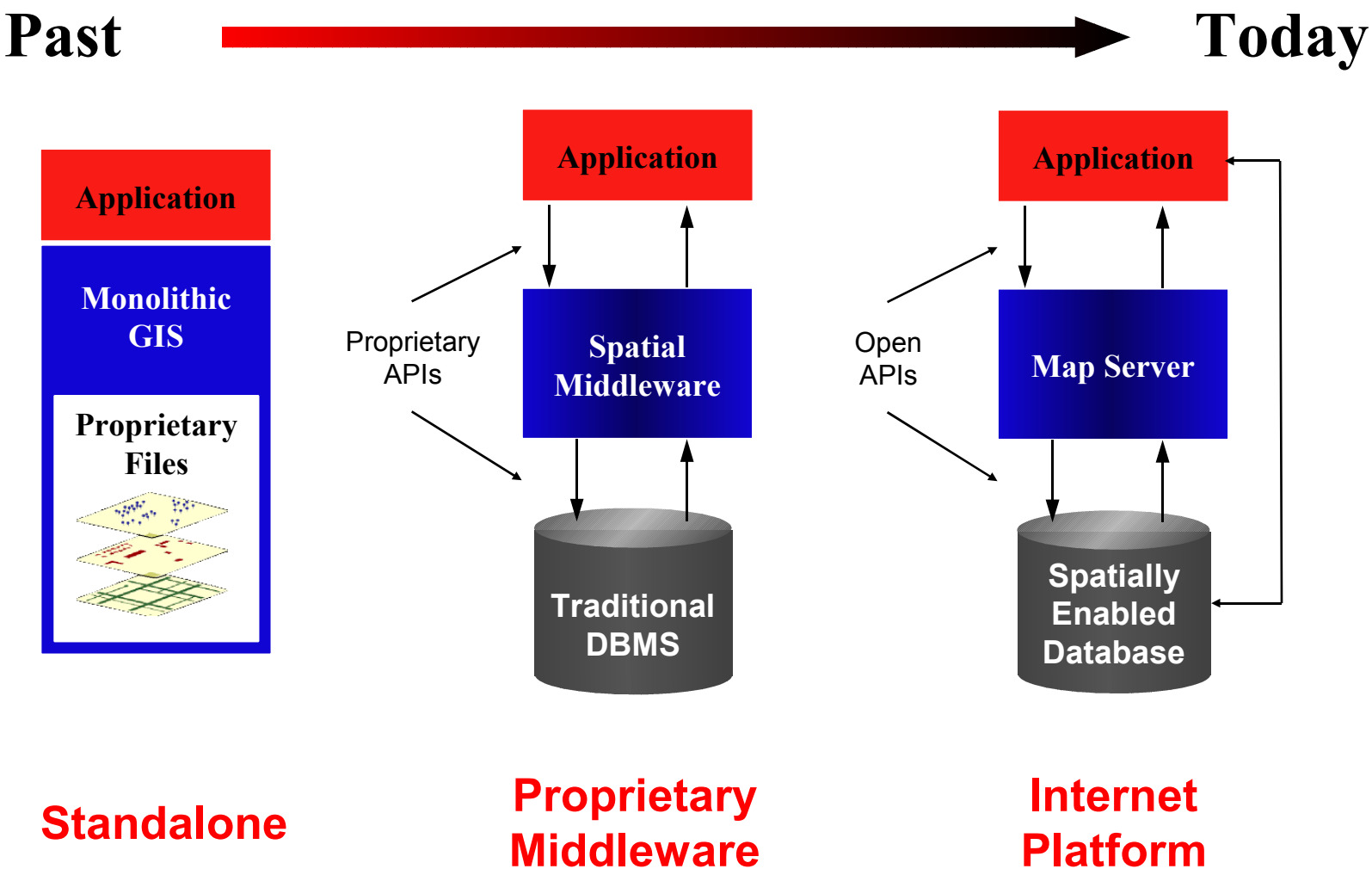
Presenter

Dan Geringer
Daniel.Geringer@oracle.com
Senior Software Development Manager
Oracle New England Development Center

In the Past
Challenge of Integrating GIS & MIS

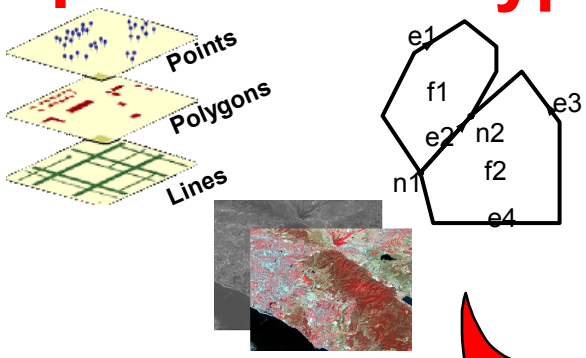


Evolution of GIS

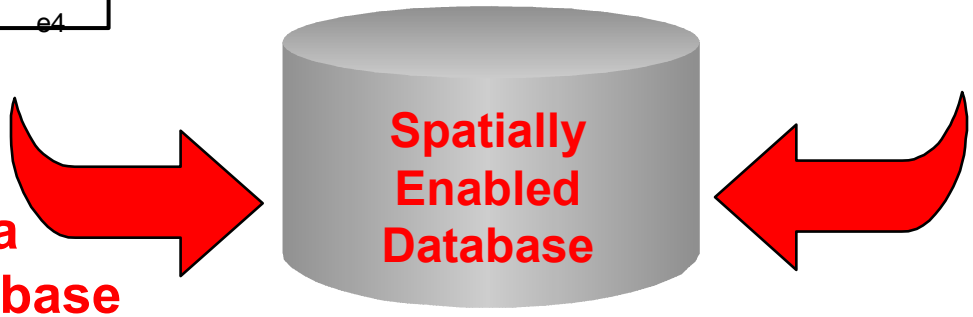


Oracle's Core Spatial Capabilities

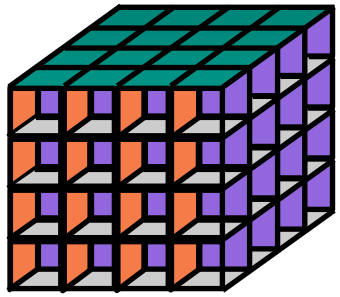
Spatial Data Types



All Spatial Data Stored in the Database (vector,raster,topology)



Spatial Indexing

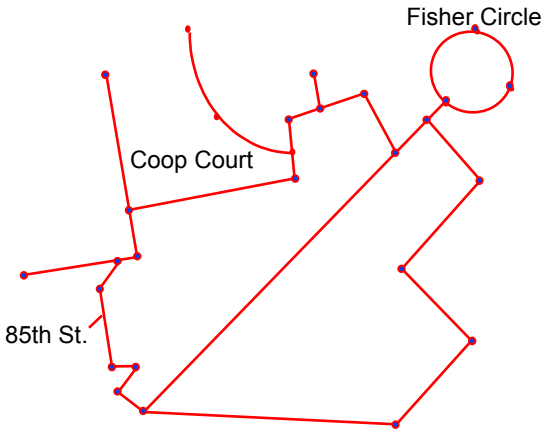


Fast Access to Spatial Data

Spatial Analysis Through SQL

```
SELECT a.customer_name, a.phone_number
FROM policy_holders a
WHERE sdo_within_distance( a.geom, hurricane_path_geom,
          'distance = 10 unit = mile') = 'TRUE';
```

Spatial Columns in Traditional Database Tables



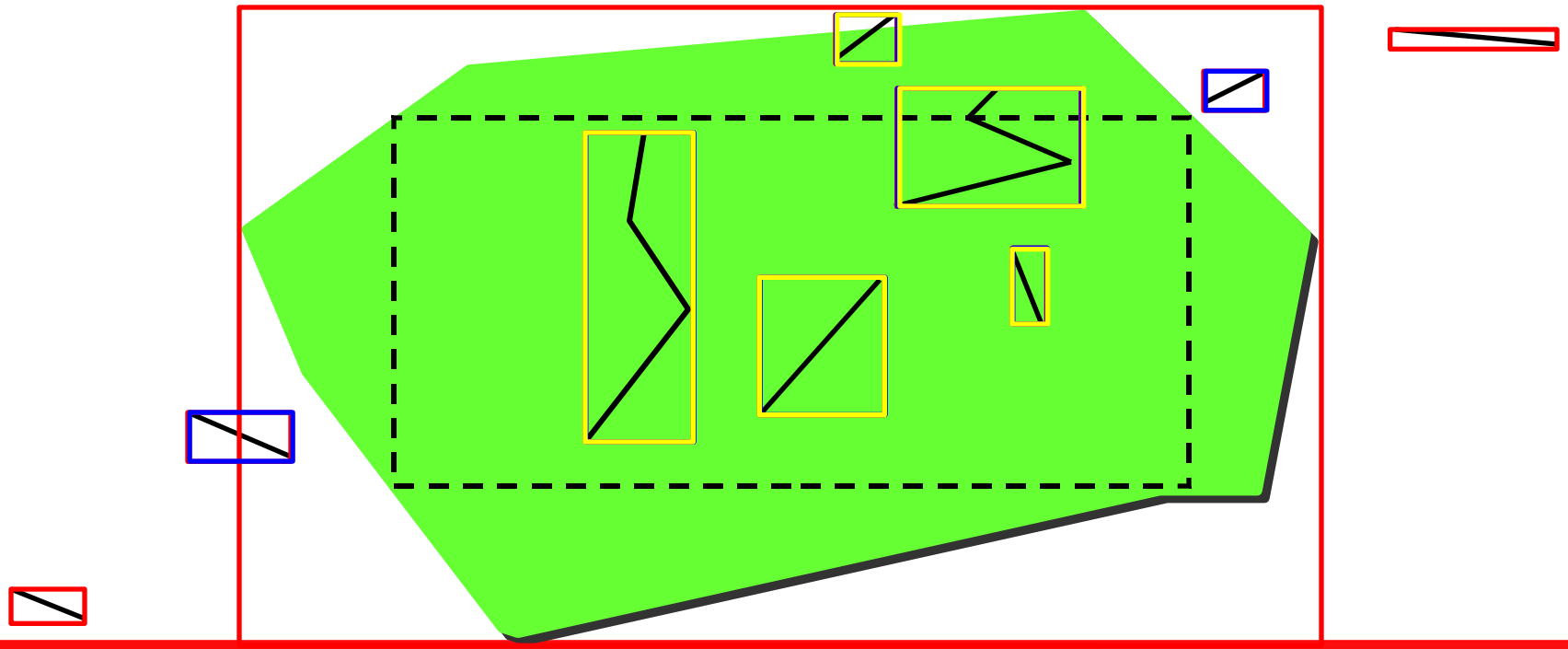
Road

ROAD_ID	NAME	SURFACE	LANES	LOCATION
1	Fisher Cir.	Asphalt	4	
2	Coop Ct.	Asphalt	2	
3	85Th St.	Asphalt	2	

R-Tree Spatial Indexing

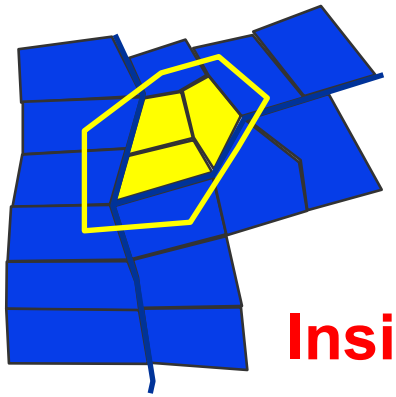
Which of millions of roads in the U.S. interact with this county?

- **First compares geometry approximations, so result is not exact.**
- **Interior optimizations are applied to candidate set.**
- **Geometry comparisons are done only where required.**

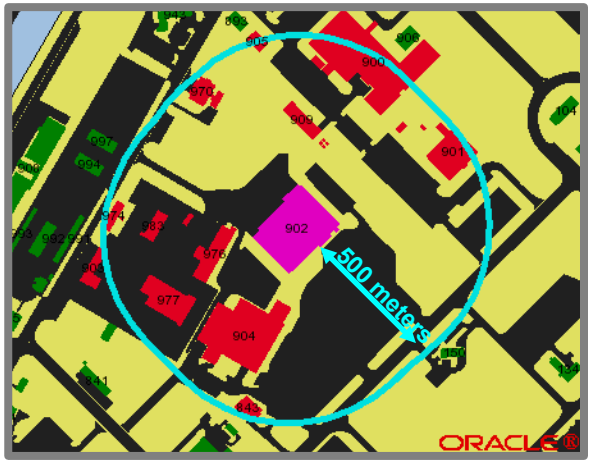


Spatial Operators

- Full range of spatial operators
  - Implemented as functional extensions in SQL
  - Topological Operators
    - Inside Contains
    - Touch Disjoint
    - Covers Covered By
    - Equal Overlap Boundary
  - Distance Operators
    - Within Distance
    - Nearest Neighbor



Inside



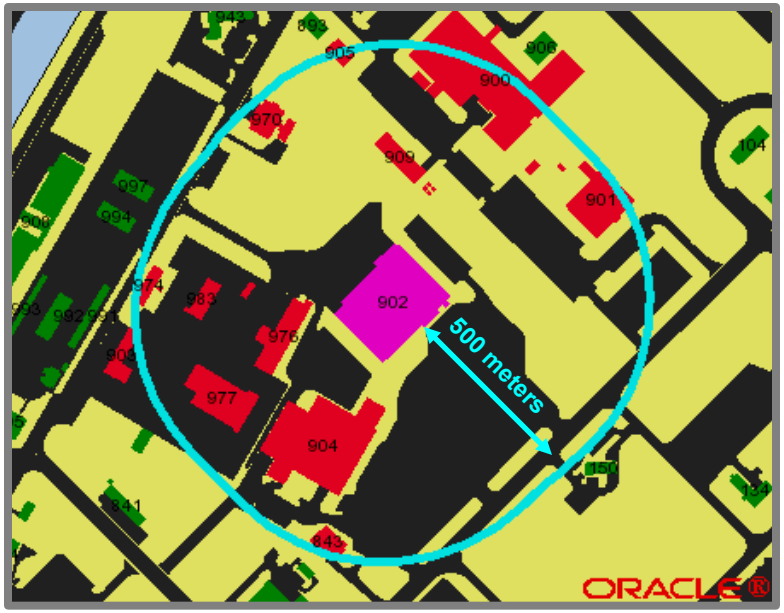
Within Distance

Spatial Query Via SQL

Find all buildings within 500 meters of building 902

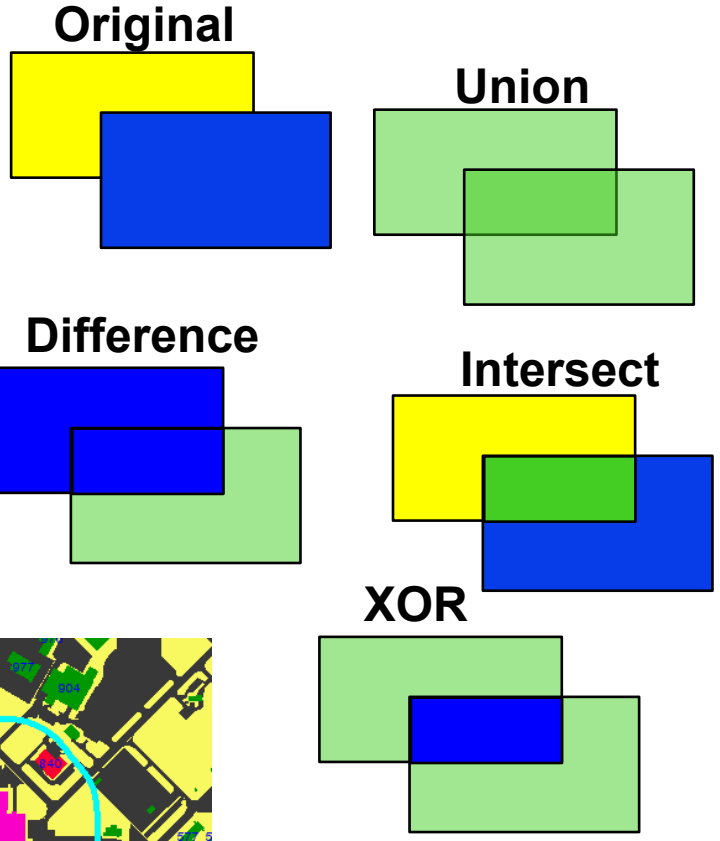
```
SQL> SELECT a.building_id
  2>   FROM base_buildings a,
  3>        base_buildings b
  4>  WHERE b.building_id = 902
  5>    AND SDO_WITHIN_DISTANCE(
  6>          a.Location, b.Location,
  7>          'distance=500 unit=meter')

  8>        = 'TRUE';
```



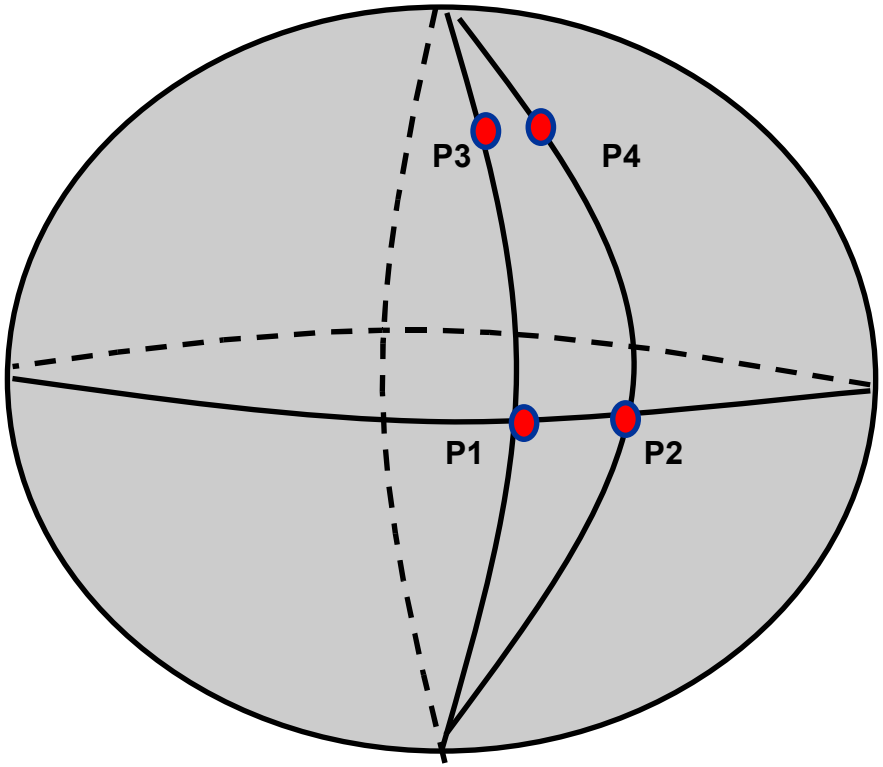
Spatial Functions

- Database Server Side Spatial Functions
  - Union, Difference, Intersect, etc.
  - Spatial Aggregates
  - Buffer
  - Point at bearing
  - To_GML
  - Geometry Validations
  - Length
  - Area
  - Distance
  - Etc…



Buffer

Longitude/Latitude Data Considerations Whole Earth Model

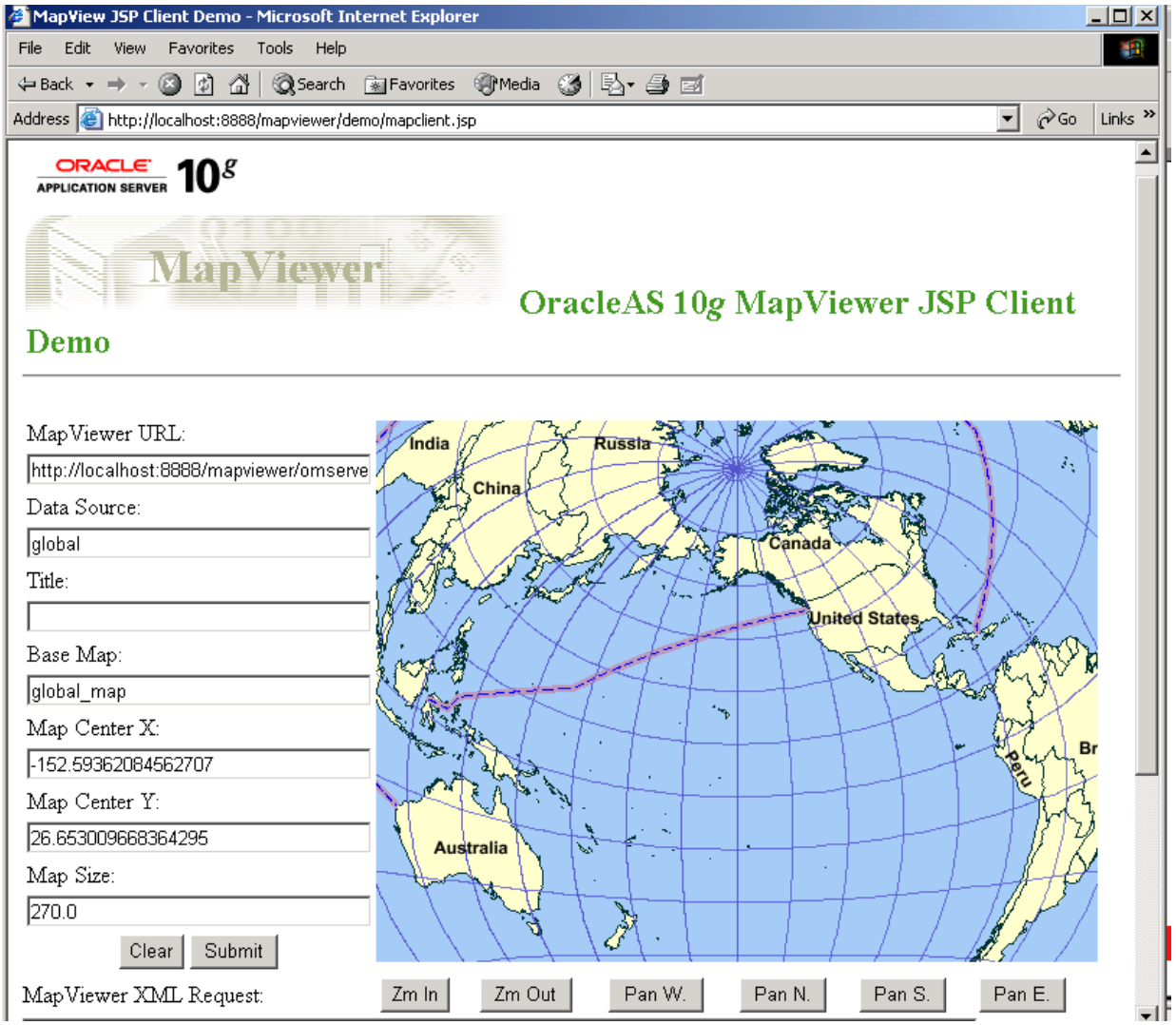


- P1 and P2 are 1 degree apart (about 111 Km apart)
- P3 and P4 are 1 degree apart (about 10 Km apart)
- Natively operate on Longitude/Latitude data

Coordinate Systems

- Whole Earth model (latitude/longitude)
  - Ellipsoidal computations
  - Accurate distance and area calculations (unit support)
  - Support for geometries that span the poles and the 180 meridian
- Projected coordinate systems
  - Cartesian computations
  - For example: UTM, State Plane, and many more…
- Non-Earth coordinates (e.g., floor plan)
- New - EPSG support - Oracle 10g Release 2

Ship Track That Crosses the 180 Meridian

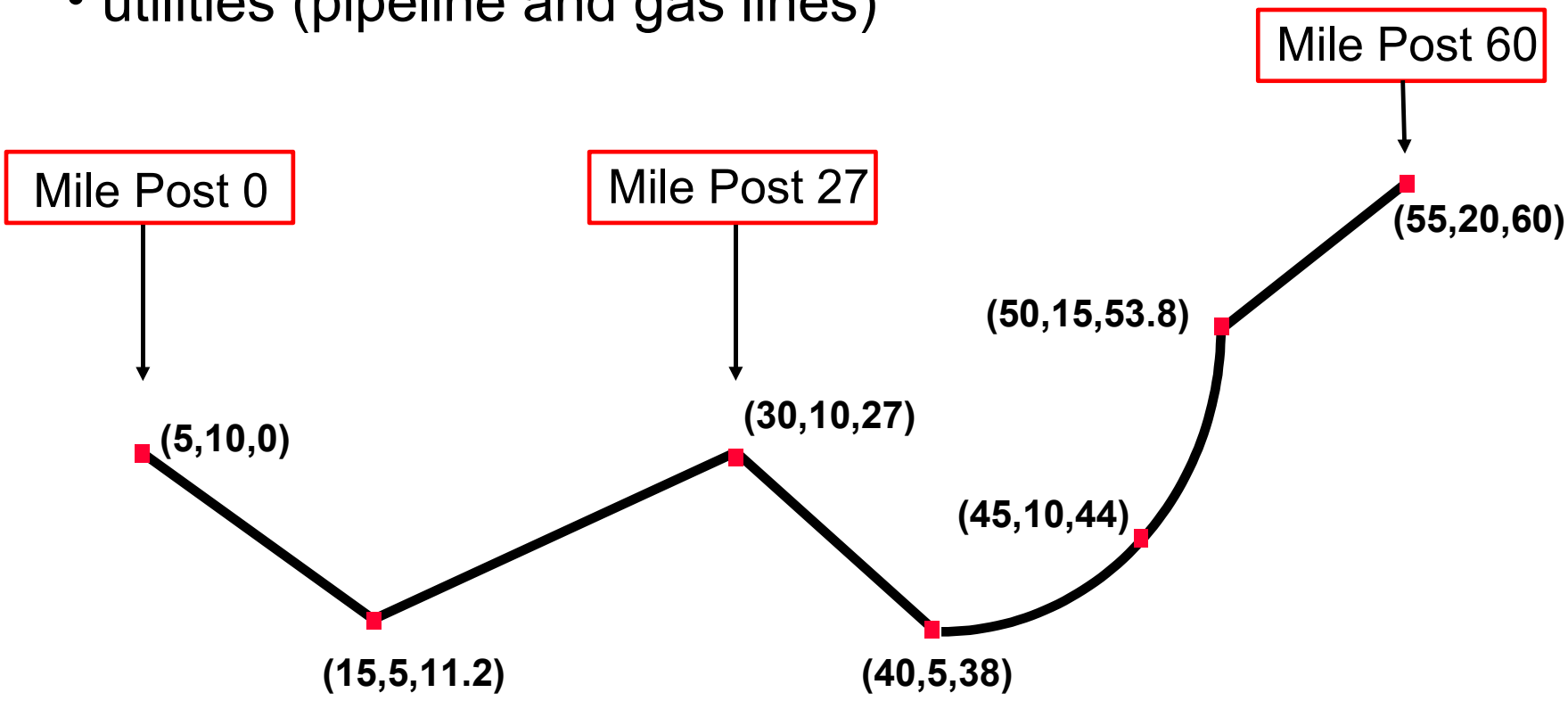


Linear Referencing Systems (LRS)

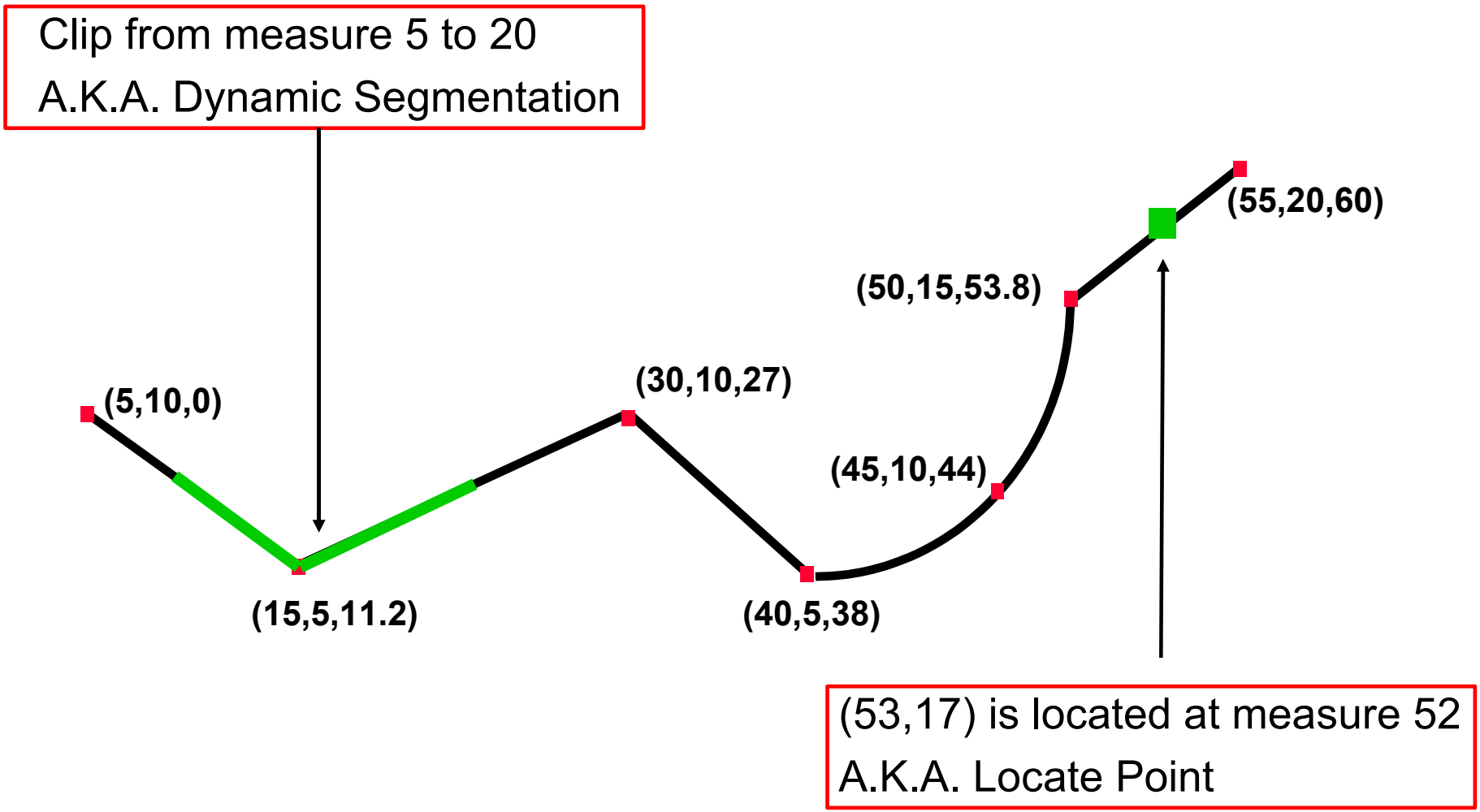
What Is Linear Referencing (LRS)?

Commonly used in many GIS applications such as:

- transportation (road network)
- utilities (pipeline and gas lines)



LRS Concepts



Pipeline Asset Management Example

System requirements

- Linear reference each section of the pipeline and store:
  - associated diameters locations
  - valve locations

Pipeline Table

PIPE_ID	GEOMETRY	INSTALL_DATE	...
SUS1105	lrs geom	05-Feb-1997	
SUS1106	lrs geom	08-Feb-1997	
SUS1107	lrs geom	09-Feb-1997	

Pipeline Asset Management Example (continued)

Pipeline Section Table

Section #	Pipe_ID	Start M.	End M.	Diameter	...
203	SUS1105	230.56	243.17	0.50	
204	SUS1105	243.17	275.84	0.48	
205	SUS1105	275.84	302.21	0.43	

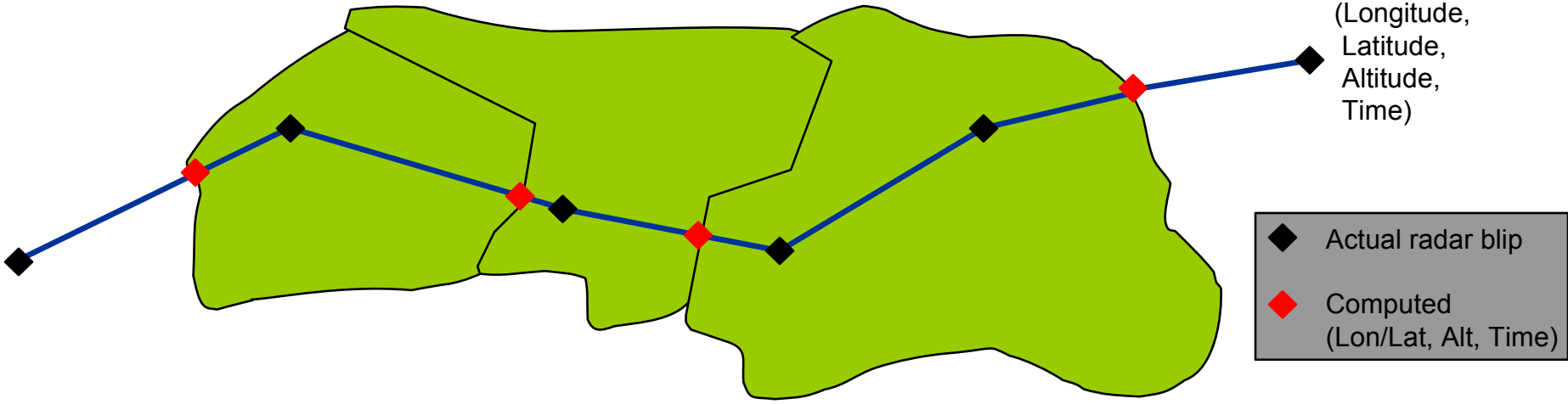
Pipeline Valve Table

Pipe_ID	Measure	Valve ID	...
SUS1105	230.56	10	
SUS1105	243.17	11	
SUS1105	275.84	12	

Note: No explicit vertices are needed to define the pipeline sections or valves

LRS Application

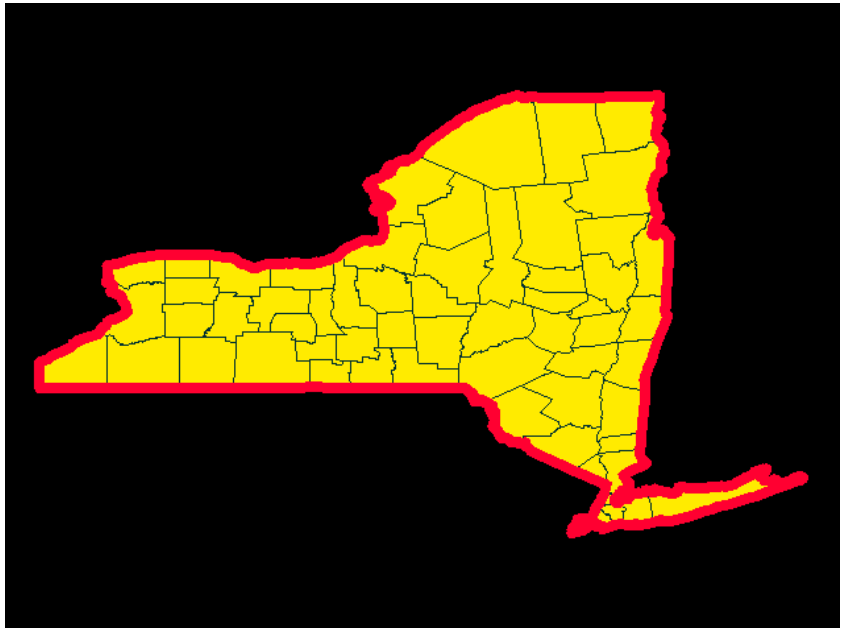
- US Airspace Boundary Crossing Application
  - Spatial functions to calculate intersection of flight paths and US airspaces.
  - Linear Referencing to interpolate the time and altitude for entry/exit points of US airspace.
  - Accurately charge foreign carriers for the amount of time in US airspace.



Spatial Aggregate Functions - Example

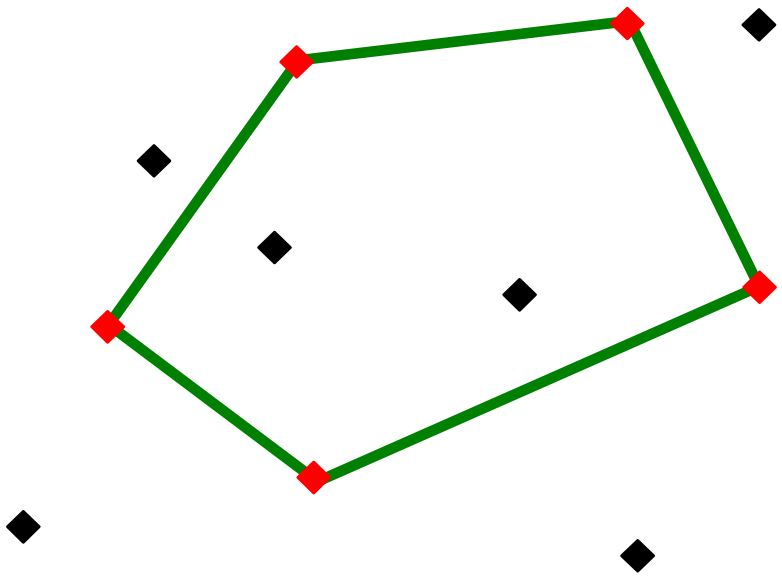
Generate New York state boundary by aggregating counties

```
SELECT SDO_AGGR_UNION(sdo_aggr_type(a.geometry, 0.5)
FROM counties
WHERE state = 'New York';
```



SDO_AGGR_CONVEXHULL

- Snap a rubber band around contaminated wells
- Dynamically generate new region
- Further analysis with new region, e.g.
  - Search for chemical plants within 5 miles of new region



Non-contaminated well

Contaminated well

GIS and Image Processing Vendors Natively Integrate Oracle Spatial

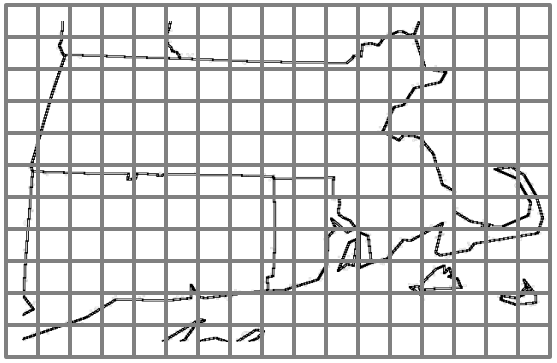
Advanced Spatial Features
Available in Oracle

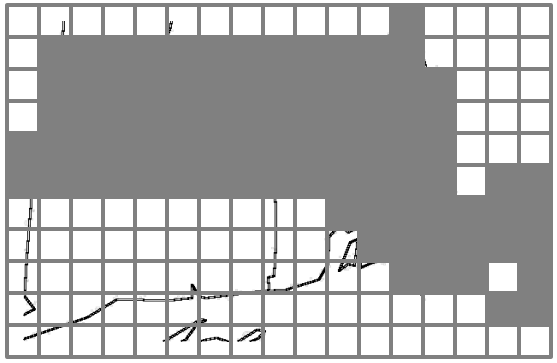
Oracle Spatial 10*g* New Features Summary

- GeoRaster data type
- Persistent Topology data type
- Network Data Model
- Spatial Analysis and Mining
- Geocoder in the database
- Routing Engine

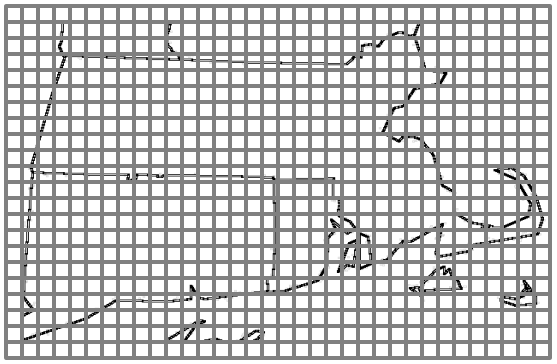
Raster Data and Cell Size

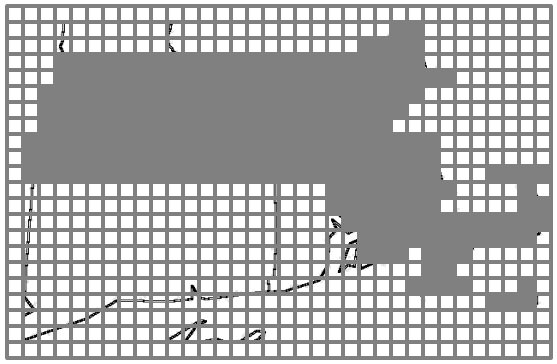
Coarser resolution



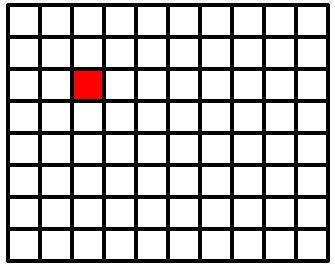
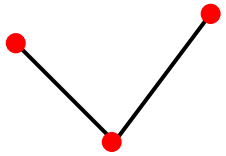
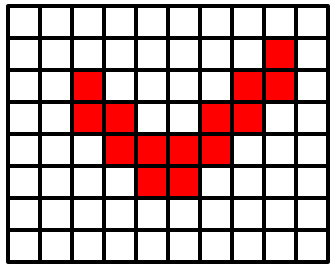
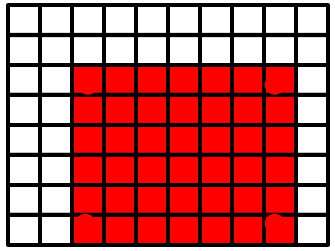


Finer resolution





Raster/Vector Data Differences

Vector Data	Vector Coordinates	Raster Data
	-74.1651749, 41.339141	
	-74.1651749, 41.339141, -73.4284481, 40.678193, -72.9792214, 41.686228	
	-74.1651749, 41.339141, -74.1651749, 39.559004, -72.9792214, 39.559004, -72. 9792214, 41.339141	

Grid Raster Data

Value Attribute Table (VAT) maps numeric values to the meaning of that value

- An example value attribute table for geological raster data

CELL VALUE	GEOLOGICAL PERIOD
1	Quaternary
2	Tertiary
3	Paleocene-Cretaceous
4	Mesozoic
5	Gondwana
6	Early Palaeozoic
7	Proterozoic
8	Early Proterozoic
9	Archaean
0	Blank Cell (no data)

Stored cell values

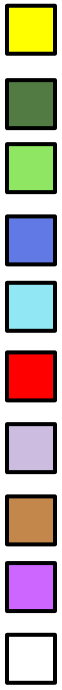
2	5	4	9	1	9	7	6
6	1	1	1	1	1	6	6
1	3	8	7	9	7	9	1
3	1	8	3	3	5	9	1
3	3	3	9	8	7	9	1
0	3	3	3	9	9	1	0
0	8	8	9	9	1	0	0
0	0	2	9	1	0	0	0

Grid Raster Data

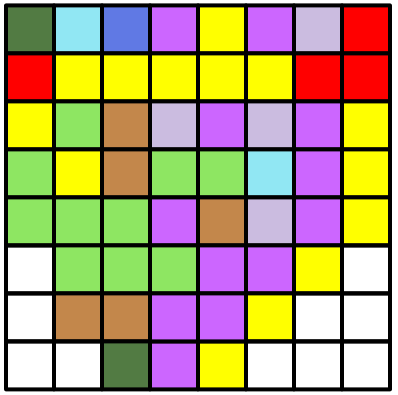
COLORMAP associates stored numeric values with colors for display

- An example COLORMAP table for geological raster data

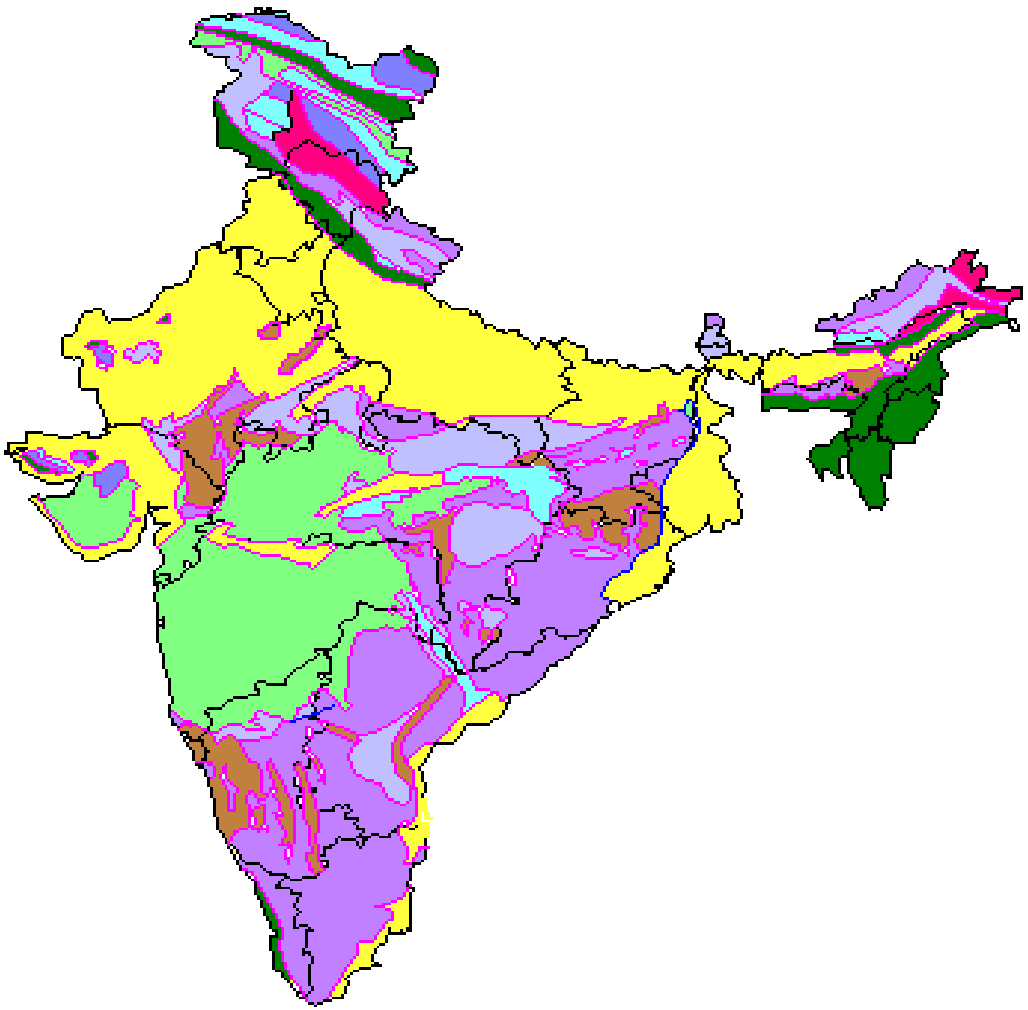
CELL VALUE	Red	Green	Blue
1	255	255	0
2	82	123	67
3	142	230	98
4	96	121	228
5	145	231	243
6	255	51	0
7	203	188	224
8	195	135	75
9	204	102	255
0	0	0	0



2	5	4	9	1	9	7	6
6	1	1	1	1	1	6	6
1	3	8	7	9	7	9	1
3	1	8	3	3	5	9	1
3	3	3	9	8	7	9	1
0	3	3	3	9	9	1	0
0	8	8	9	9	1	0	0
0	0	2	9	1	0	0	0



Geological Map of India (Grid Raster Data)



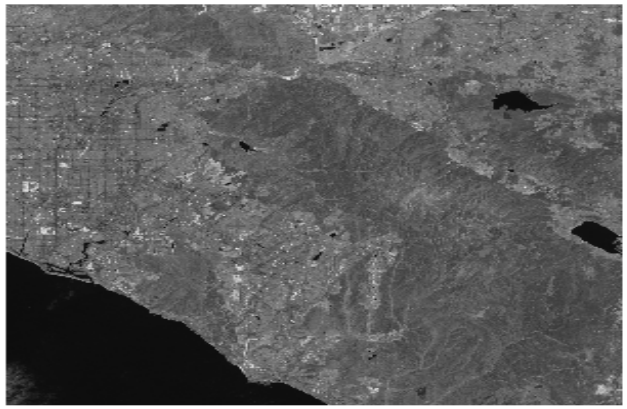
- Quaternary
- Tertiary
- Paleocene-Cretaceous
- Mesozoic
- Gondwana
- Early Palaeozoic
- Late Proterozoic
- Early Proterozoic
- Archaean

Raster Data Concepts – (Digital Imagery)

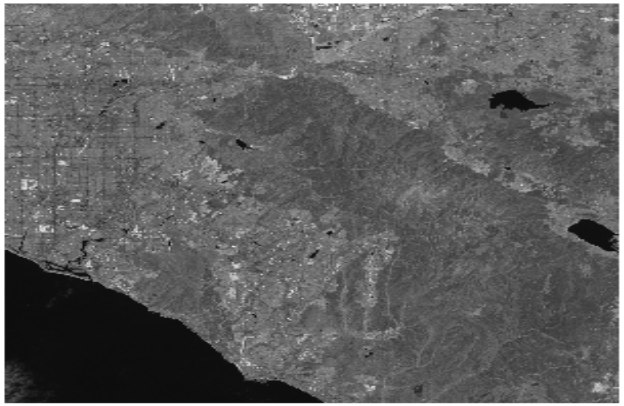
- **Digital Imagery** - a specialized type of raster data
  - Examples include:
    - Satellite imagery
    - Airborne photographs
    - others…

Image Data

TM Band 2



TM Band 3



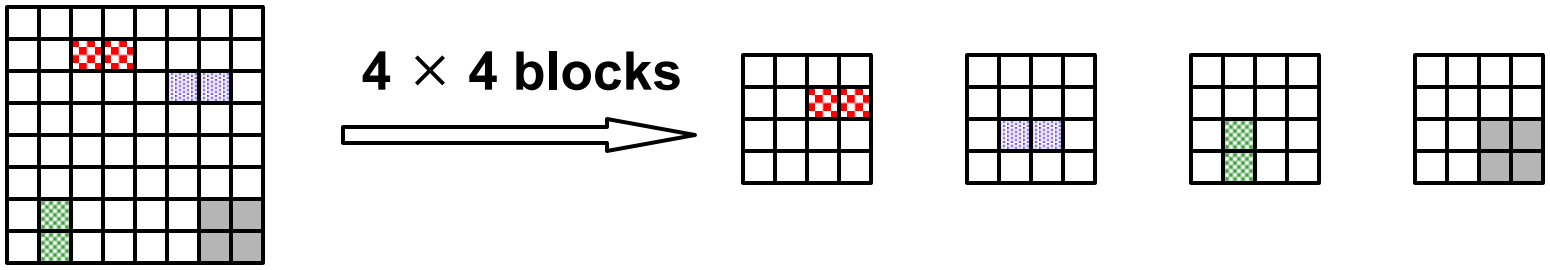
TM Band 4

TM Band 432

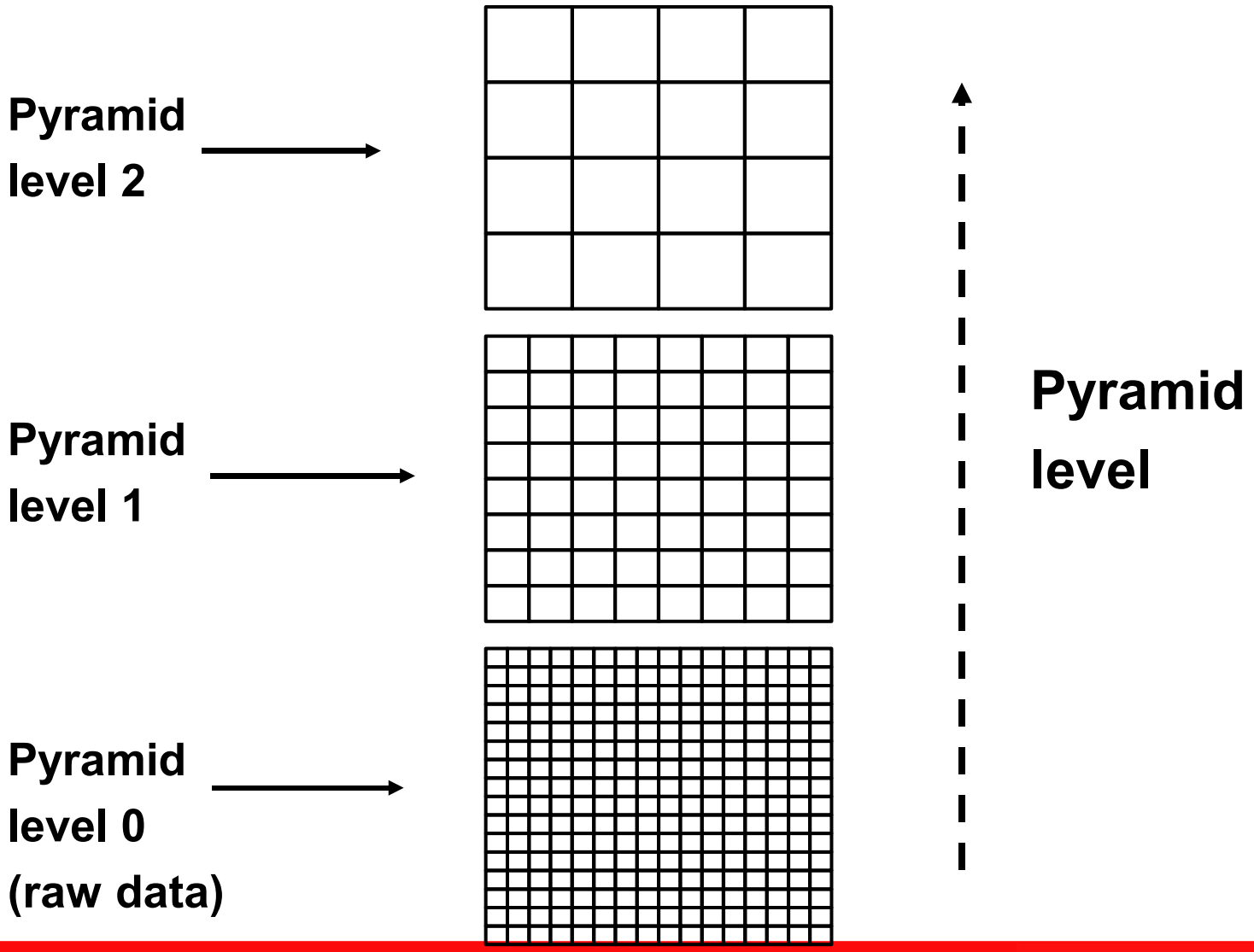
Some bands may accentuate different features

Blocking

- One image can be Gigabytes in size
- Index very large rasters into smaller blocks
- Blocked data is also interleaved
  - Band sequential (BSQ)
  - Band interleaved by pixel (BIP)
  - Band interleaved by line (BIL)



Pyramids


Pyramid level 2
Pyramid level 1
Pyramid level 0 (raw data)
Pyramid level

GeoRaster - Features/Functionality

- Store, index, and retrieve raster data
- Store, maintain, and retrieve GeoRaster metadata
- Analysis functionality:
  - Generate pyramids
  - Copy
  - Change format: Interleaving, blocking
  - Subset: Crop, cut, clip 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/Georeferenced images supported

GeoRaster: Compression
New in Oracle 10g Release 2

- Natively support two industry standard compression techniques
  - JPEG (lossy)
    - JPEG-B (abbreviated baseline JPEG format)
    - JPEG-F (full-format baseline JPEG format)
  - DEFLATE (lossless)
    - (a.k.a. ZIP)
- All GeoRaster operations work on compressed/uncompressed GeoRaster objects
  - Automatic decompression on sub-set operations

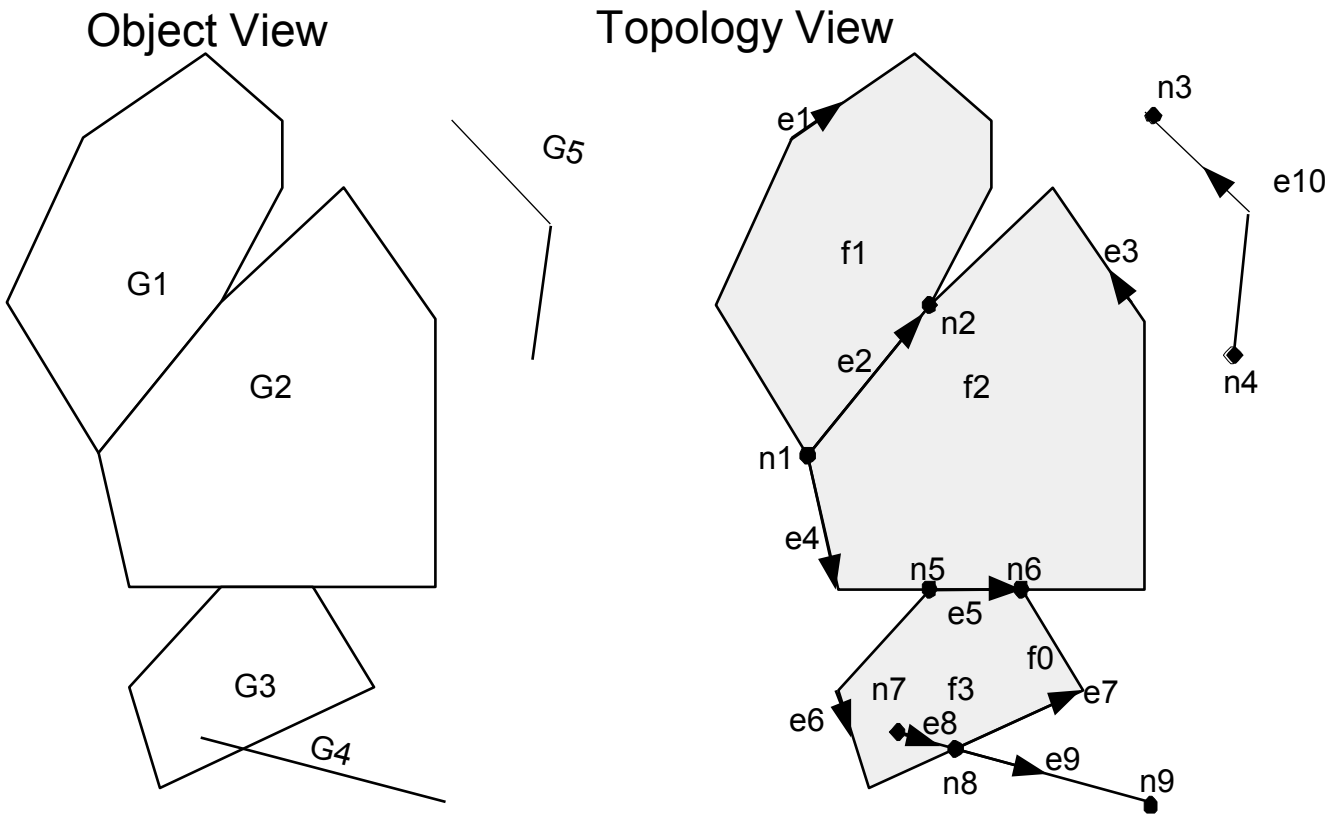
Advanced New Feature
Geocoder

- Geocoding Engine included in the database
- Generates latitude/longitude (points) from address
- Supports:
  - International addressing standardization
  - Formatted and unformatted addresses
  - Transaction and batch capabilities
- Base data available from NAVTEQ & TeleAtlas
  - Navteq partners (eSpatial and ADCI)
  - Download sample data from NAVTEQ
- Servlet model – new in 10g Release 2
- Working with Gempi for Brasil support

Advanced New Feature
Router

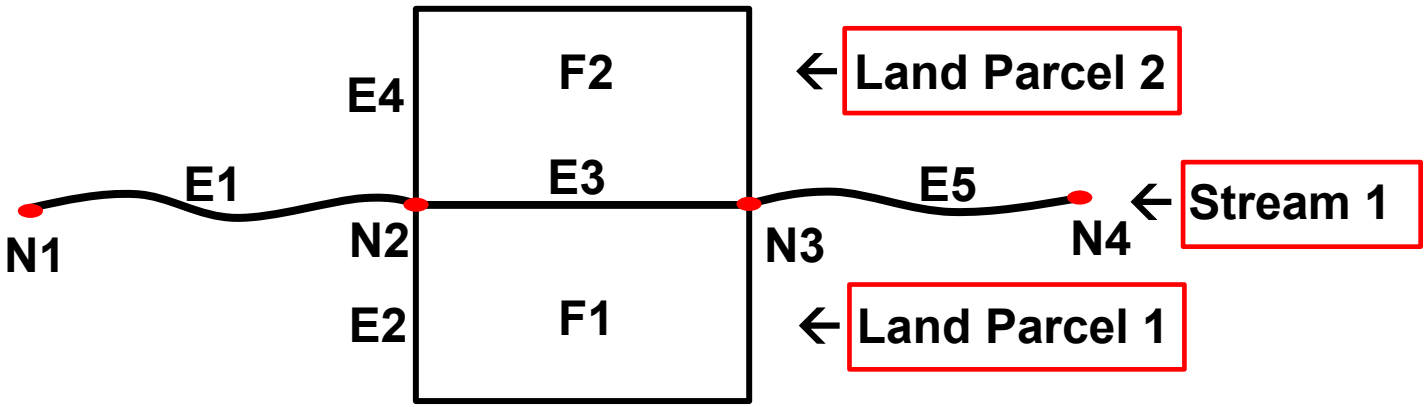
- Routing algorithms included in the database
- Generates driving directions
- XML API
- Base data available from NAVTEQ & TeleAtlas
  - Download sample data from NAVTEQ
- Working with Gempi for Brasil support

Advanced New Feature
Persistent Topology



Topology Example

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

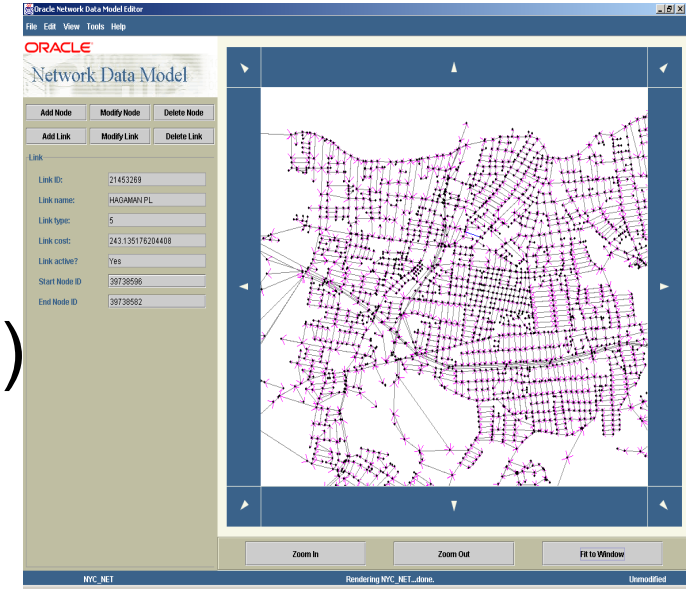


Hierarchical Feature Model: Example

- Parcel features are stored in a level 0 feature layer
  - Each parcel is derived from topological primitives (faces).
- Neighborhood features are stored in a level 1 feature layer:
  - Each neighborhood is derived from a list of parcels.
- School District features are stored in a level 2 feature layer:
  - Each school district is derived from a list of neighborhoods.

Advanced New Feature
Network Data Model

- Open Data Model For Graph Analysis In the Database
- Supports Network solutions (Tracing & Routing)
  - Transportation and Transit Solutions
  - Field Service, Logistics
  - Location based Services
  - and Telematics
- Bio-Info Pathways (Life Sciences)
  - Biological Pathways
  - Protein-Protein Interaction



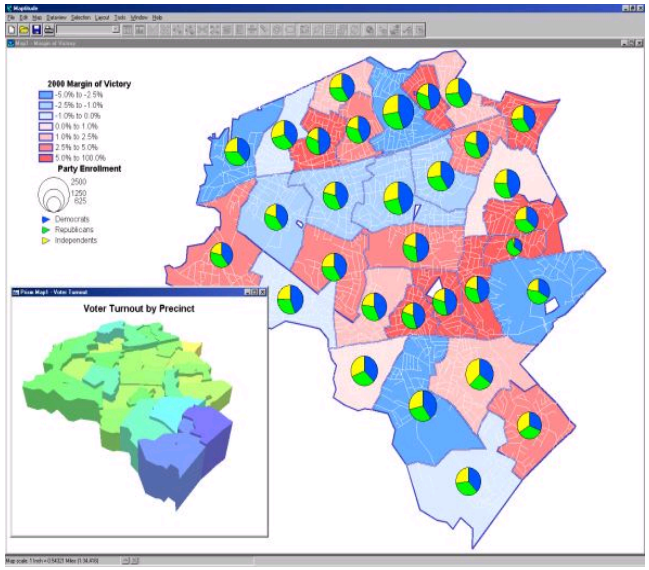
Advanced New Feature
Spatial Analysis and Mining

- *Everything is related to everything else, but nearby things are more related than distant things.*

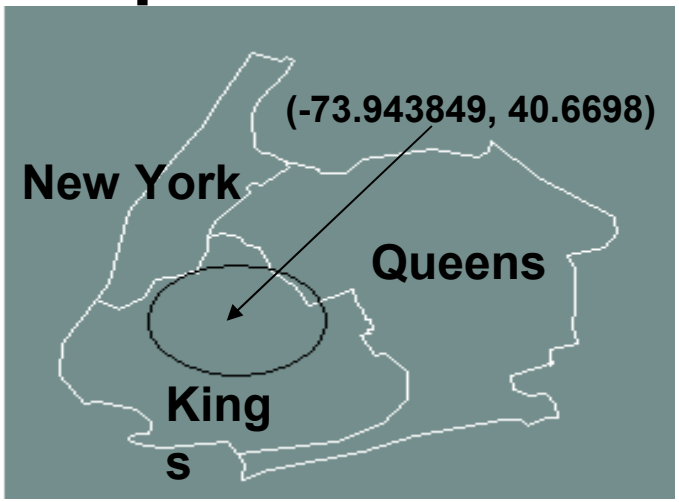
Tobler's first law of geography

Spatial Analytic Functions

- Discovery based on Spatial Patterns
  - Cluster analysis
  - Location prospecting



SDO_SAM.AGGREGATES_FOR_GEOMETRY: Example



COUNTY	ST	TOTPOP	% COUNTY COVERED BY WINDOW
Queens	NY	1951598	00.5437756
Kings	NY	2300664	31.0430579
New York	NY	1487536	00.0188785

```
SELECT SDO_SAM.AGGREGATES_FOR_GEOMETRY(
  'GEOD_COUNTIES', 'GEOM',
  'sum', 'totpop',
   SDO_GEOMETRY(2001, 8307,
     SDO_POINT_TYPE(-73.943849, 40.6698,NULL),
     NULL, NULL),
  'distance=3 unit=mile')
FROM DUAL;
------------------------
723570.362
```

Standards Are Important
SQL/MM Methods and OGC Standards

- GET_WKB() – Get Well Known Text
- GET_WKT() – Get Well Known Binary

```
set long 500;
SELECT A.GEOM.GET_WKT()
FROM polygon_table a
WHERE id = 1;


A.GEOM.GET_WKT()
----------------
POLYGON ((146.0 66.0, 148.0 66.0, 148.0 68.0, 146.0 68.0,
          146.0 66.0))
```

Make Sure Your Spatial Strategy Leverages Important Core Database Features

- **Table partitioning**
  - For scalable solutions, maintenance and performance
- **Label Security**
  - Row level security policies on your data
- **Spatial Analysis via SQL**
  - Use non-proprietary spatial data types
  - Spatial applications don’t always need a GIS
- **Spatial Analysis inside stored procedures, triggers and functions**
- **Replication**
- **Native database long transaction support**
- **Grid computing architecture**

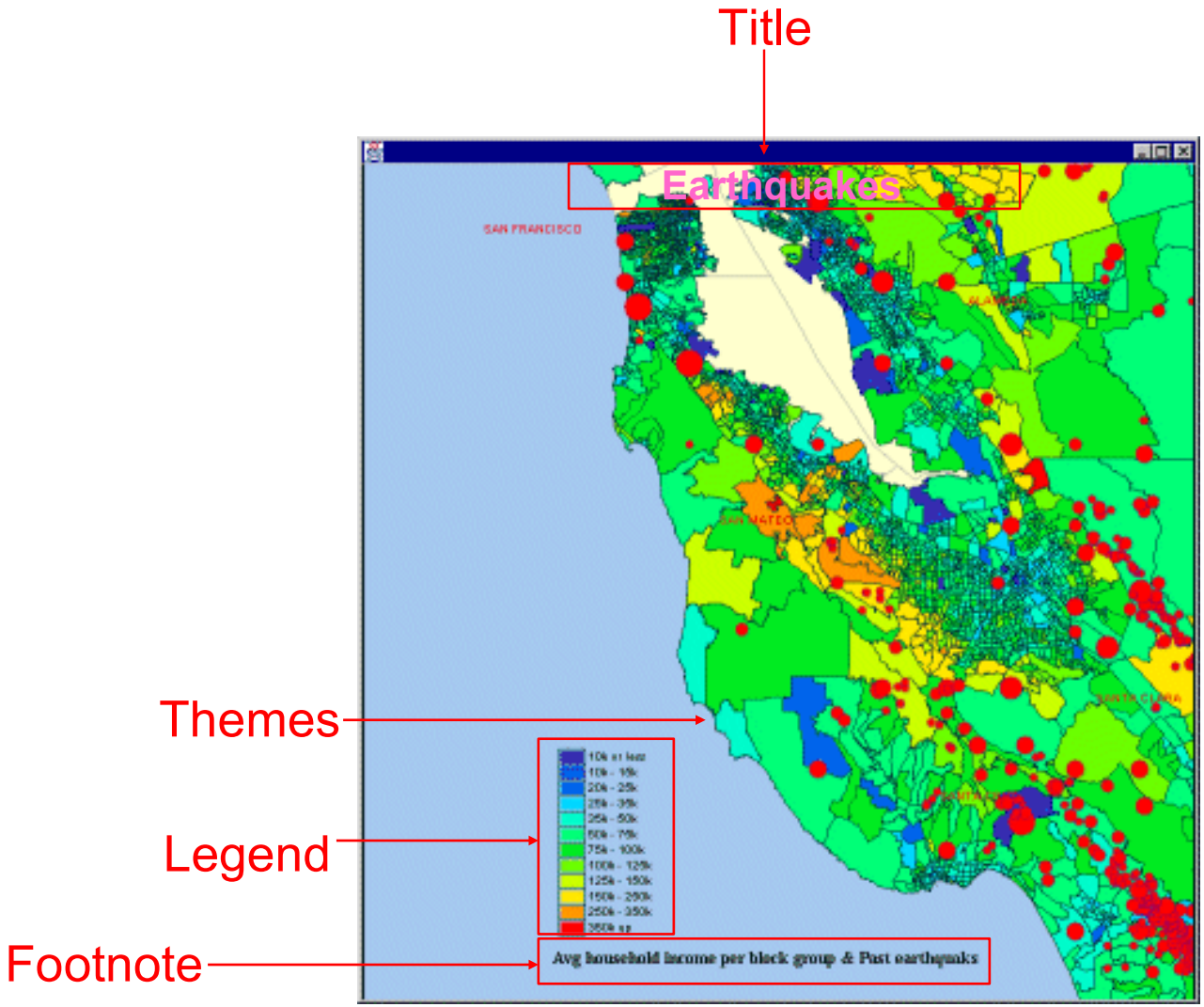
Oracle Application Server 10*g*
MapViewer

Oracle Application Server 10^{g} MapViewer

- Web Map Server
  - Standard feature of the Oracle Application Server
  - Integrated with Oracle Spatial and Oracle Locator
- Easily publishes data stored in Oracle's native spatial data type (SDO_GEOMETRY) to the web
- Provides the following API's:
  - XML
  - Java
  - JSP Tag library
  - OGC Web Map Service

Oracle Application Server 10^{g} MapViewer

Native Support For Map Visualization



OGC Compliant Web Map Service (WMS)

- Style, Theme and Map definitions stored in the database (in SVG and XML formats)
- Supports the following requests:
  - **`GetMap`**
  - **`GetFeatureInfo`**
  - **`GetCapabilities`**
- Application Server Map Visualizers can:
  - Generate OGC WMS compliant maps
  - Render OGC WMS compliant maps generated by another OGC compliant WMS
  - Render vector and raster data on maps generated by another OGC compliant WMS

Oracle10^{g} Locator & Spatial Features

Oracle Locator 10^{g} release 2

- All Data Types
- Spatial Operators
  - Topological
  - Distance
- Distance Function
- SDO_UTIL package
- Coordinate Transformation
- Long Transactions
- Table Partitioning*
- Object Replication*
- Oracle Label Security

Bundled Feature
Standard & Enterprise Edition

Oracle Spatial 10^{g} release 2

- All Locator features
- GeoRaster Data Type
- Topology Data Type
- Network Data Model
- Geocoding
- Routing
- Linear Referencing
- Spatial functions
  - aggregates
  - buffer, centroid, union,etc

Licensed Option
Enterprise Edition Only

Spatial Applications Don't Always Need a GIS

- Every organization wants to cut costs
- Oracle Spatial Technologies Bundle
  - Oracle Locator
    - Oracle Standard Edition
    - Oracle Enterprise Edition
  - Oracle Application Server MapViewer
    - Java Edition
    - Standard Edition
    - Enterprise Edition
- Leverage what you own


Questions
&
Answers