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Oracle Spatial and Graph

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DATABASE 12^c

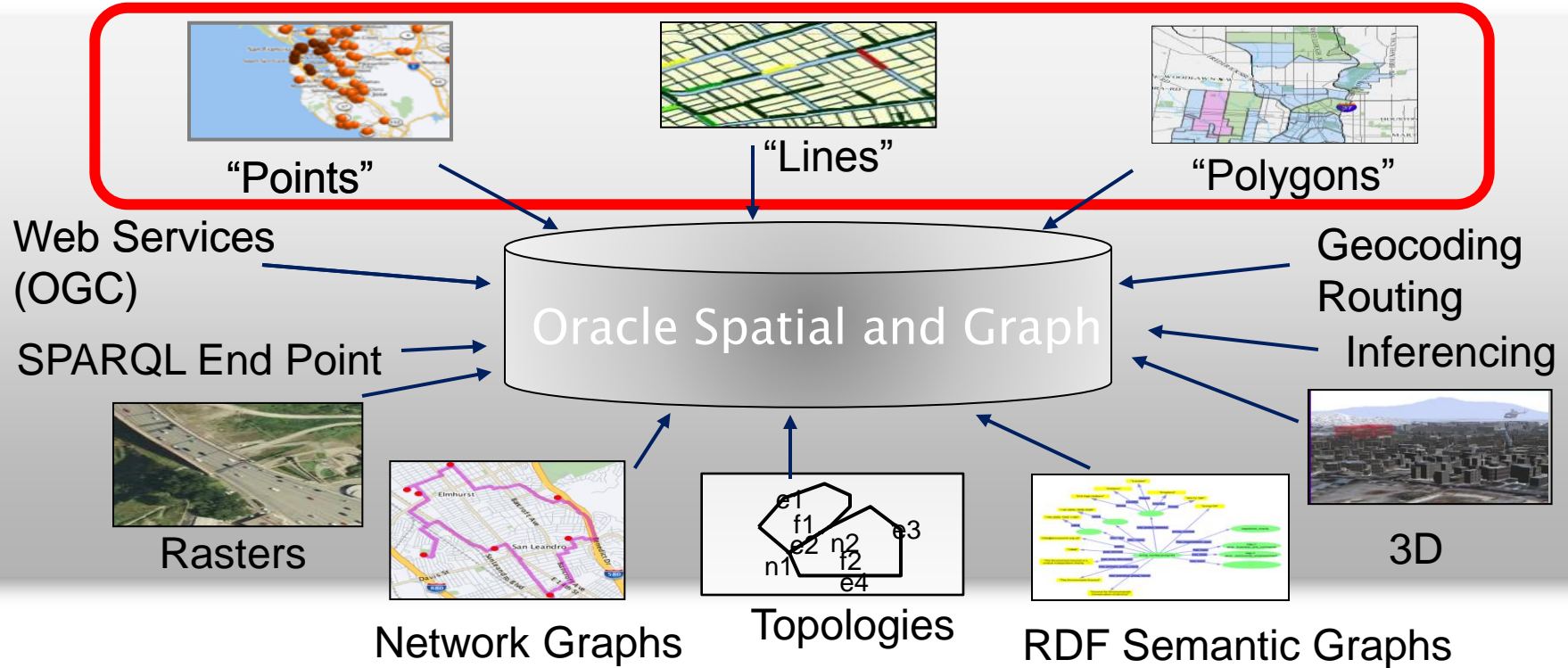


Plug into the **Cloud**.

Agenda

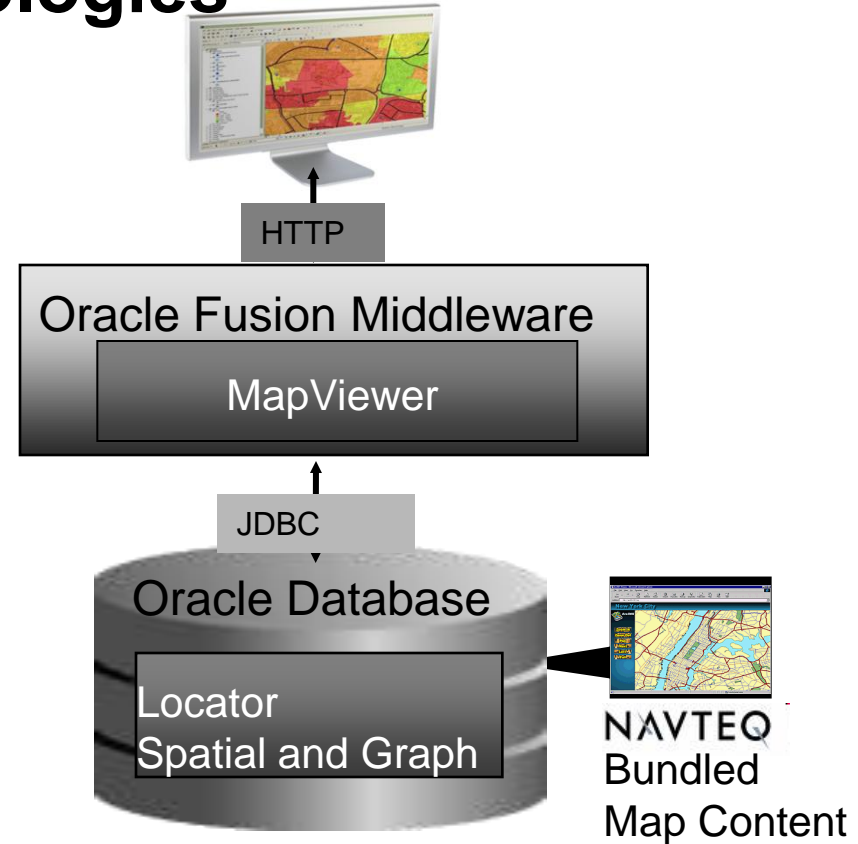
- Introducing Oracle Spatial and Graph
- Goals for Spatial Features in 12c
- New Spatial and NDM Graph Features in 12c
- Goals for RDF Graph Features in 12c
- New RDF Graph Features in 12c
- Unique advantages using Exadata

Oracle Spatial and Graph option



Oracle's Spatial Technologies

- **Oracle Locator**: Feature of Oracle Database XE, SE, EE
- **Oracle Spatial**: Priced option to Oracle Database EE
- **MapView**: Java application and map rendering feature of Oracle Fusion Middleware
- **Workspace Manager**: Long transactions feature of Oracle Database SE, EE
- **Bundled Map Content**: Major roads, administrative boundaries (city, county, state, country) - worldwide coverage from Navteq



INTRODUCING

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**Oracle
Spatial and Graph**

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Why rename this Oracle Database option

From “Oracle Spatial” to “Oracle Spatial and Graph”

- Highlights existing graph capabilities in Oracle Spatial
 - W3C RDF graph since Oracle 10gR2
 - Network Data Model graph since Oracle 10gR1
- Addresses increasing market demand for graph database capabilities
 - Social Network Graph database popularity
 - Multimodal and integrated transportation, utility and communications networks

Spatial Features



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Our Spatial Technology Strategy

- **Location-Enable the Oracle Stack**
 - Oracle Spatial and Graph, Oracle Database Locator
 - Oracle Fusion Middleware MapViewer
- **Partnerships With Leading Spatial Vendors**
 - Software vendors
 - Integrators
 - Data suppliers
- **Commitment To Standards**
 - Open Geospatial Consortium, SQL, ISO TC-211, TC-204
- **Part of Oracle applications, tools, engineered systems**
 - Exadata, Exalogic, Exalytics
 - Oracle Business Intelligence Enterprise Edition, Fusion, e-Business, CRM, Primavera, Utilities, Retail and more

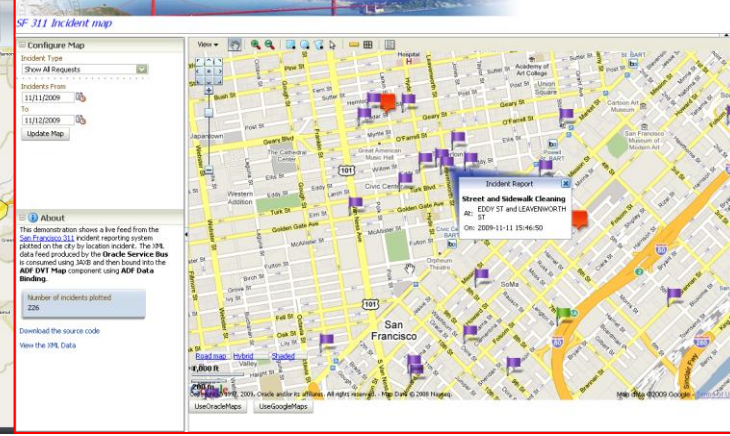
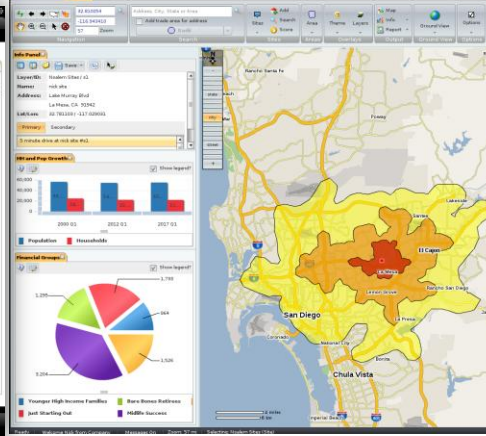
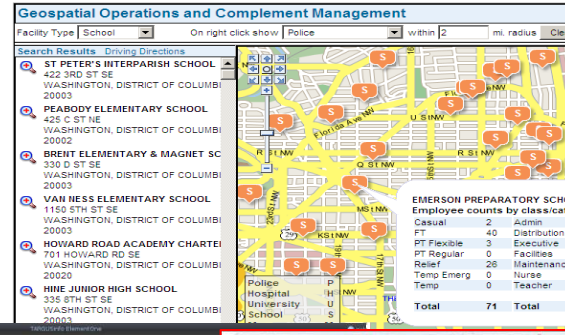
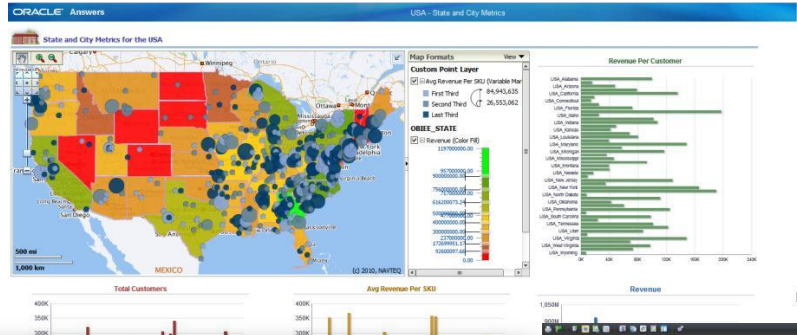


Most Widely Deployed Spatial Database

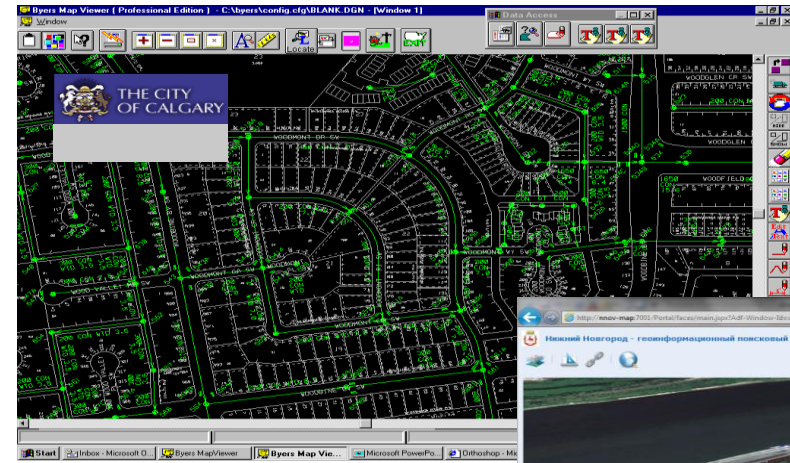
- **Utilities**
 - Omaha Public Power, Reliant, Southern, US DoE, Western Power Corp, Severn Trent, Beijing Power, Georgia Power, Czech Telem, Copenhagen Energy, Electrable, Gaz de France, Hydro-Quebec, Equitable Resources, Nova Naturgas, Sao Paulo Electric, Xcel Energy
- **Telco & Wireless LBS**
 - AT&T, Bell South, British Telecom, Cingular, DoCoMo, KDDI, Intrado, JPhone, Nextel, Sprint, T-Mobile, Telkom, Telenor, Telstra, Telus, Telia, Cellcom, Verizon, VIAG, Vodaphone, Wind
- **Transportation Management**
 - German Rail, Austrian Rail, California, Iowa, Florida, Maine, Maryland, Minnesota, New York, Oklahoma, Pennsylvania, Alabama, Alberta, London Rail, Netherlands Transport, Australia,
- **Local Authorities**
 - Berlin, Dutch Police, New York City, Chicago, Los Angeles, San Jose, San Mateo, Washington DC, Cleveland, Detroit, Phoenix, Winnipeg, Vancouver, Edmonton, Stockholm...
- **National Mapping, Cadasters & Hydrographic Agencies**
 - Ordnance Survey (UK, IR, NI), US Census, NIMA, USGS, US Army, Denmark, Sweden, The Netherlands, Poland, Australia, Singapore Land Authority

Location-Enabled Business Applications

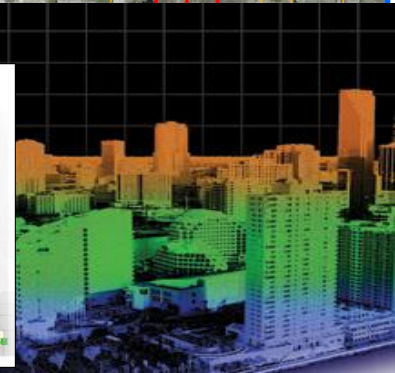
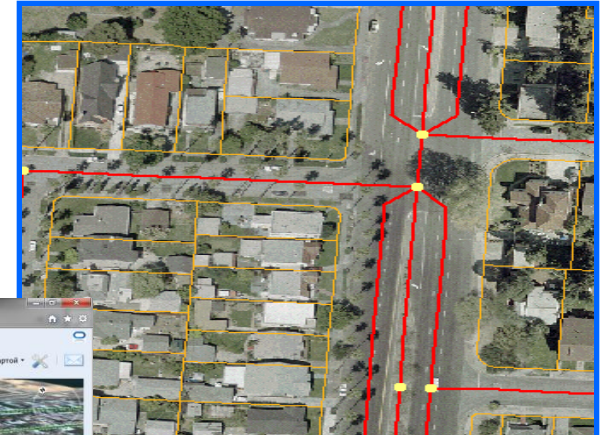
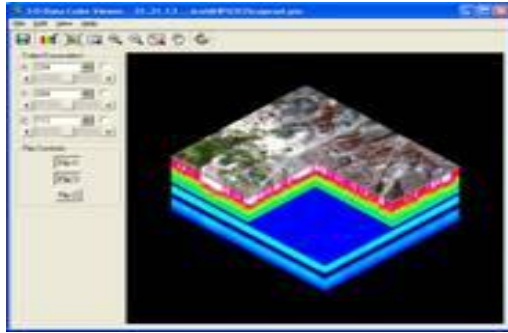
Geocoding
Spatial searches
Routing
Mapping



Specialist Geospatial Applications



Geometry
Topology
GeoRaster
Networks
LRS
Geodetic
Long Transactions
3D (Point clouds,
LIDAR)



Mature Spatial Platform

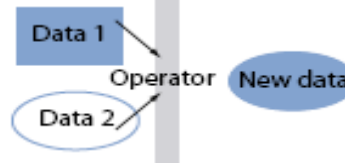
- Fusion Middleware MapViewer
- ADF GeoMAP Component

- Spatial and Graph
 - Network Data Model Graph
 - GeoRaster
 - Topology Data Model
 - Linear Referencing
 - 3D

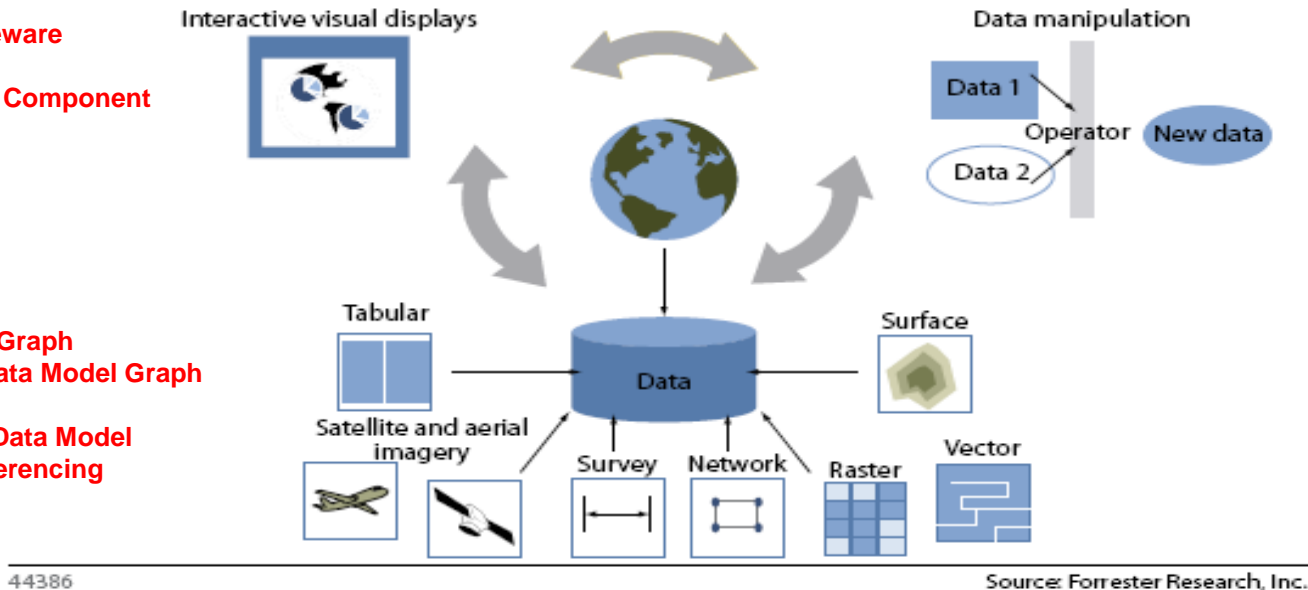
Interactive visual displays



Data manipulation



- Fusion Middleware MapViewer
- Spatial APIs
- Toplink
- Partner tools



44386

Source: Forrester Research, Inc.

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Goals for Spatial Features

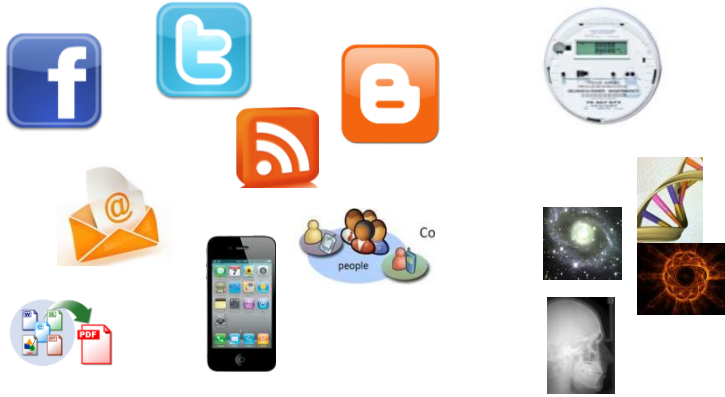
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DATABASE



Plug into the **Cloud.**

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Big Data Requirements



- Device-generated data
- Documents
- Location data
- Audio, Video, Image
- Social Network and Interaction Models



Advances with Oracle Database 12c

New Spatial Features

Dramatic
Performance



Simplified
Application
Development

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Core Spatial Functions and Operations

Performance

Oracle Database Locator

ANYINTERACT, INSIDE:
20-30x

GEOM DISTANCE: 40X

WITHIN DISTANCE: 10X

VALIDATE GEOMETRY: 4X

Vector Performance Acceleration

“Turbo-charger” feature for spatial functions and operators

Spatial and Graph option Performance Improvements



```
graph LR; A[Spatial and Graph option Performance Improvements] --> B[Join: 50-100x]; A --> C[Touch: 50x]; A --> D[Contains, Overlaps: 50x]; A --> E[Complex masks: 50x];
```

Operation	Performance Improvement
Join	50-100x
Touch	50x
Contains, Overlaps	50x
Complex masks	50x

Join: 50-100x

Touch: 50x

Contains, Overlaps: 50x

Complex masks: 50x

Vector Performance Acceleration

“Turbo-charger” feature for spatial functions and operations

Spatial Performance Improvements



A diagram with a central red box on the left containing the text 'Spatial Performance Improvements'. Four lines radiate from the right side of this box to four separate gray boxes on the right. The boxes are arranged vertically and contain the following text: 'GEOM.relate: 5-10x', 'DML single insert: 3x', 'Coordinate System Transformations: 40-50%', and 'General DML operations: 30-50%'.

GEOM.relate: 5-10x

DML single insert: 3x

Coordinate System
Transformations: 40-50%

General DML operations:
30-50%

Improved performance

Core Spatial Functions and Operations



SPATIAL INDEX STATISTICS

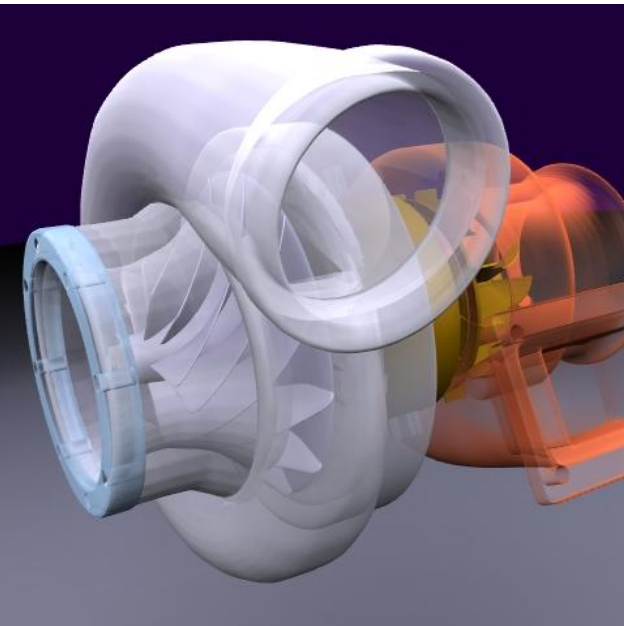
- New Algorithms to Collect Spatial Index Statistics
- Optimized Execution Plans

20-90% REDUCTION IN REDO LOGS

- Improved DML Performance
- Less Storage Required

Vector Performance Acceleration

Oracle Spatial and Graph “Turbo-charger” feature



OPTIMIZED METADATA QUERIES

- Kernel level caching
- Performance gains for DMLs and Spatial function calls
- Optimization especially noticeable in workflows with many fast running queries

Parallel Raster Operations



- MANY RASTER FUNCTIONS CAN PARALLELIZE
- SERIAL OPERATIONS PERFORM UP TO 3X FASTER
- SCALES TO OVER 100X FASTER ON HIGHLY PARALLEL SYSTEMS

3D Point Cloud data

US Army Corps of Engineers is making extensive use of the Point Cloud data type in Oracle Database Spatial and Graph option to store, retrieve, subset and analyze LiDAR data used to model 3D landscapes to support in-theatre, mission-critical DoD operations. ... [W]e are storing more than 150Tb of data including 100Tb of point cloud data (with more on the way). A single instance currently stores more than 1 Trillion points,” said Michael Smith, US Army Corp, Remote Sensing Center.

The enhancements to Oracle Spatial and Graph in Oracle Database 12c have dramatically increased scalability for multisession point cloud creation and provide a considerable savings of storage space.

Michael Smith
US Army Corp, Remote Sensing Center

Advances with Oracle Database 12c

Spatial Features

Dramatic
Performance



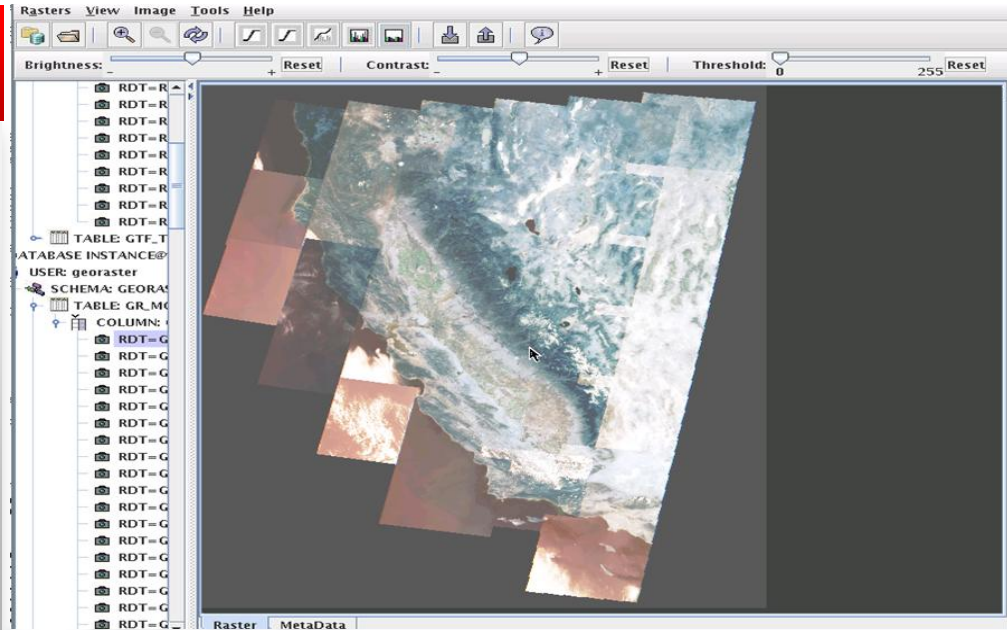
Simplified
Application
Development

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Virtual Mosaic and Image Processing

In Database Processing

- Virtual Mosaic of collections of any georeferenced GeoRaster objects
- Advanced spatial queries and on-the-fly transformation and mosaics
- Raster Algebra operations to create new map products
- Image Processing: Masking, stretching, segmentation, rectification



Mosaic of Landsat Images

Parametric curve support

NURBS Non-Uniform B Splines

- Used for highway and rail design, and surface models
- Mathematically precise representation of freeform surfaces and curves



Enhanced 3D and Point Cloud Support

Simpler and More Robust

- Simplified Java API for 2D and 3D in memory functions
- Pyramiding support for PC and TIN data
- Contour generation from PC data
- 3D Geodetic Support

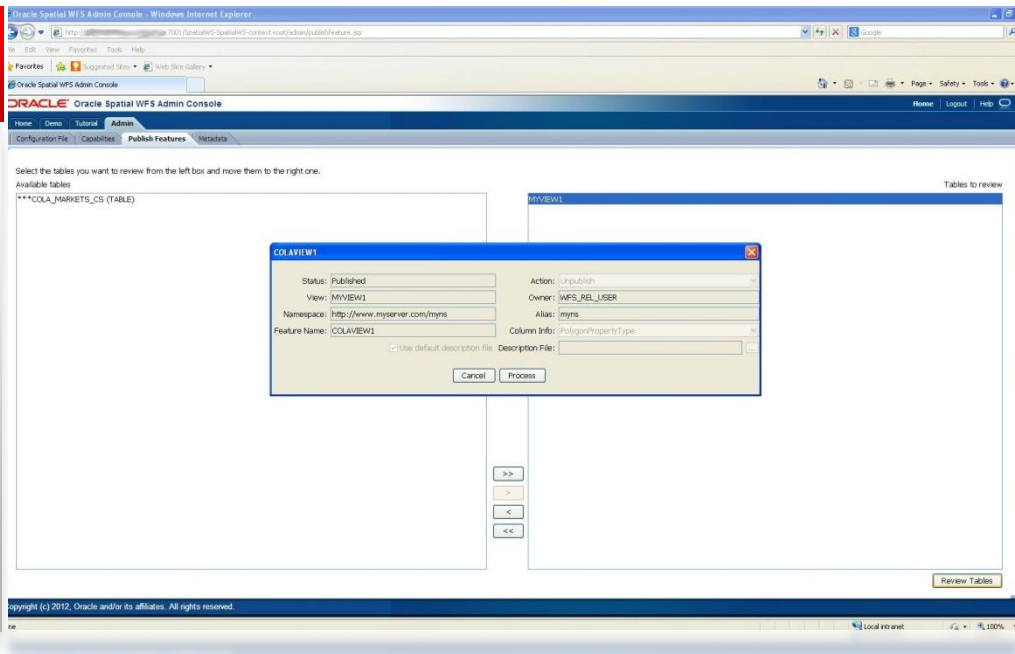


Oracle Spatial and Graph

Open Geospatial Consortium Web Feature Server 1.1

Web-based console

- Menu driven GUI simplifies registration of 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



Summary of New Spatial Features

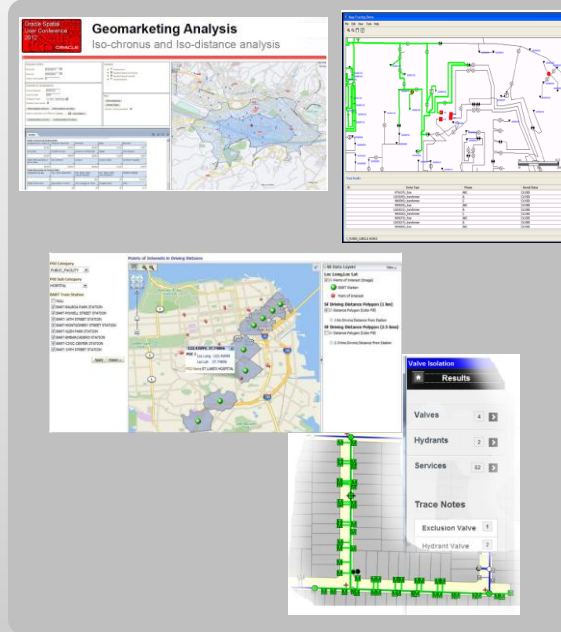
- Vector Performance Acceleration
- Parallel GeoRaster and Enhanced Raster Operations
- Parametric Curve Data Type
- Extended 3D and Point Cloud data type functionality
- Web Feature Server Console

Network Data Model graph

Use Cases



**Oracle
Spatial and
Graph**



- Road and Multimodal Networks
- Drive Time Polygon Analysis
- Trade Area Management
- Service Delivery Optimization
- Water, Gas, Electric Utility, Network Applications

Oracle Spatial and Graph

Network Data Model Graph

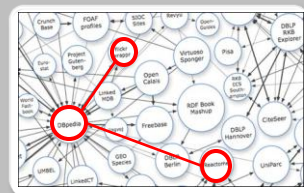
- A storage model to represent graphs and networks
- Graph tables consist of links and nodes
- Explicitly stores and maintains connectivity of the network graph
- Attributes at link and node level
- Logical or spatial graphs
- Can logically partition the network graph
- Java API to perform Analysis in memory
- Loads and retains only the partitions needed
- Dynamic costs with real time input
- Shortest path, within cost, nearest neighbors
- Traveling salesman, spanning tree, ...
- Multiple Cost Support in Path/Subpath Analysis

RDF Semantic Graph

Use Cases

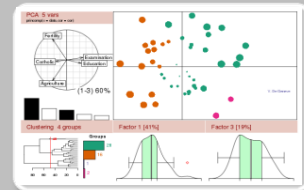
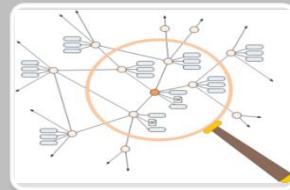
Linked Data & Public Clouds

- Unified content metadata model for public clouds
- Validate consistency



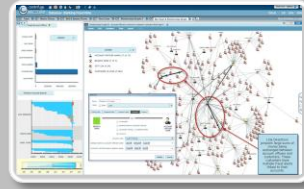
Text Mining & Entity Analytics

- Find related content & relations by navigating connected entities



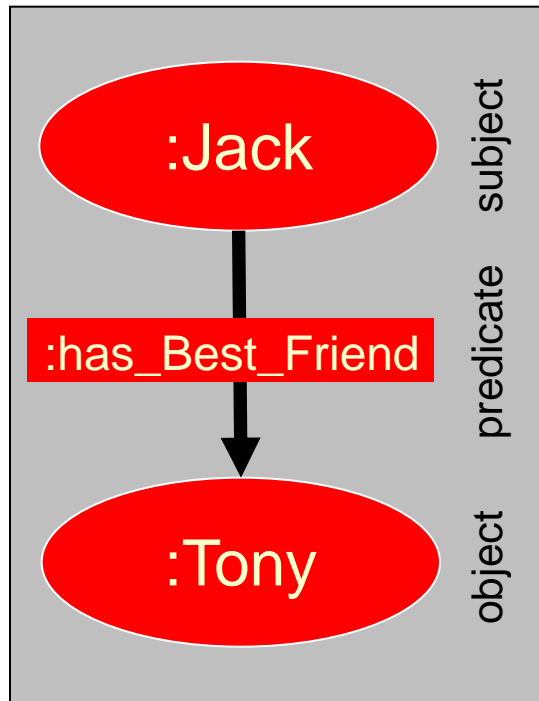
Social Media Analysis

- Analyze content using integrated metadata
 - Blogs, wikis, video
 - Calendars, IM, voice



What is RDF?

Resource Description Framework



- Basic structure is a “triple”
- RDF can be serialized into XML
- Schemas need not be specified in advance
- RDF data is fully expressible as RDBMS data
- And
- RDBMS data is also expressible as RDF

Oracle Spatial and Graph

RDF Semantic Graph

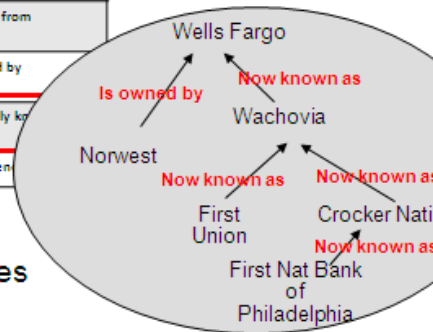
The Only RDF Database with:

- Graph assisted SQL querying
- Fine-grain Label-based Security
- Support for both SPARQL and patented SQL access
- Works with OBIEE, Oracle BPM, Oracle Advanced Analytics
- Full spatial analysis of all 2D, 3D and raster data

Conceptually, Semantic applications look at things as being represented as graphs, rather than tables

Type of Relationship	What you evaluate	What you compare	Opposite/Inverse Relationship
Lends to	Businesses and related parties	Businesses	Borrows from
Owns	Institutions and related parties	Institutions	Is owned by
Now known as	Corporate names and symbols	Corporate names	Previously known as
Operates in	Geographic hierarchy	Geographic name	No present

In Oracle Database, we use Triples and Key relationships to represent nodes and links in the Graph.



Oracle Spatial and Graph

RDF Semantic Graph

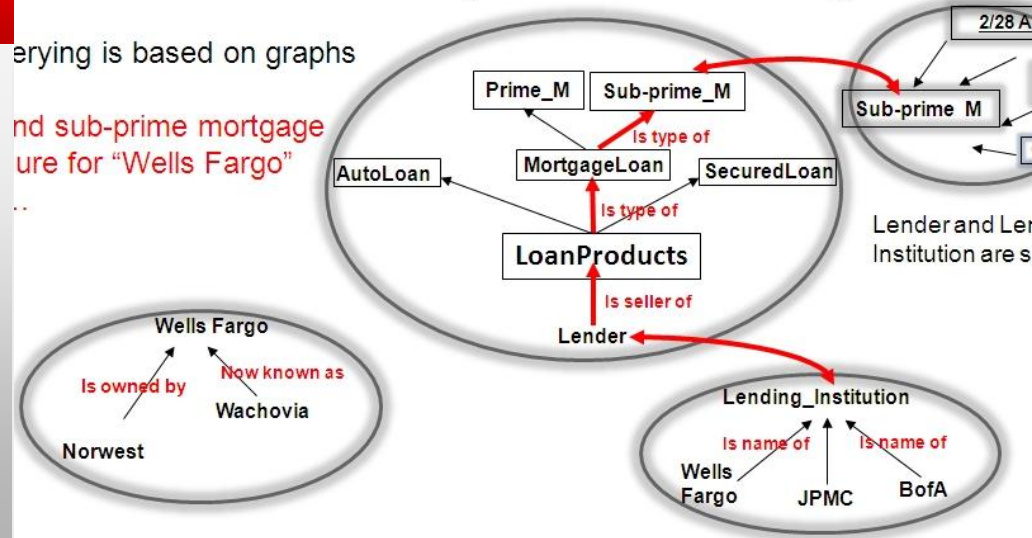
Mature, complete RDF Database

- Supports all relevant W3C standards
- Supports Latest SPARQL Query Language, Tools and Web Services
- View relational data as RDF triples
- Scales with hardware – petabytes of triples
- 60% data compression reduces storage and enhances performance

Fundamental Concepts and “building blocks”

Everything is based on graphs

Prime and sub-prime mortgage
are for “Wells Fargo”



Advances with Oracle Database 12c

Graph Features

Dramatic
Performance

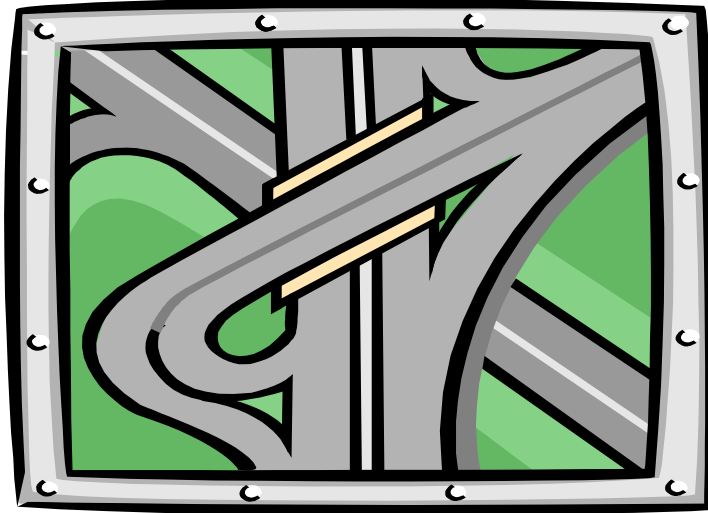


Simplified
Application
Development

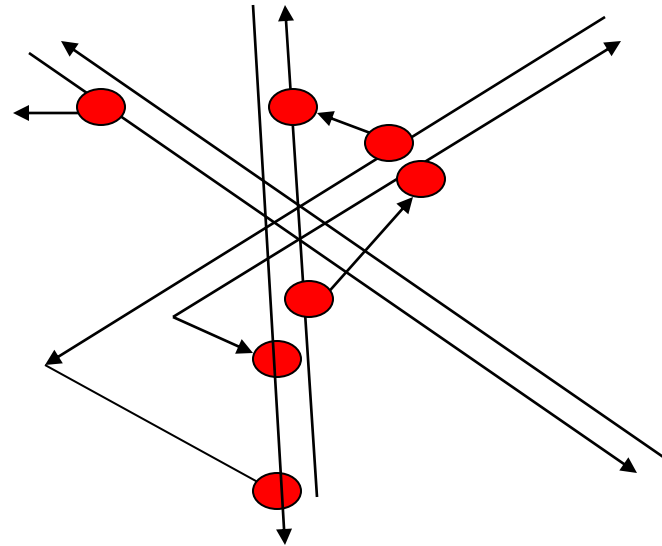
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Real World Feature Modeling in NDM Graph

Feature Representation



Network Representation



Network Data Model Graph

Temporal Modeling/Analysis

- Traffic Patterns
 - Record historical travel
 - Based on time of day and day of the week
- NDM can use traffic patterns to compute shortest paths
- Support NAVTEQ Traffic Patterns format out of the box

Shortest Path Analysis
Left click for start point, right click for end point, or manually enter node ID, link ID@percentage, or address.

Start | 199488837

End | 199919135

Network Constraints

(Hold ctrl key for multi-select or de-select)

custom.NoHighwayConstraint

custom.ProhibitedZoneConstraint

oracle.spatial.router.ndm.TruckHeightConstraint

oracle.spatial.router.ndm.TruckLegalConstraint

Prohibited Zone

Draw

Link Cost Calculators

custom.TrafficLinkCostCalculator

Keep Previous Results ☒

Reverse Direction ☐

Include Traffic data ☒

Start Time | 10:00 PM

Find Shortest Path

Analysis Result:

(199488837~199919135)

[cost:946.05814, 105 links]

Time to analyze the network: 0.467s.

Time to compute geometries: 0.035s.

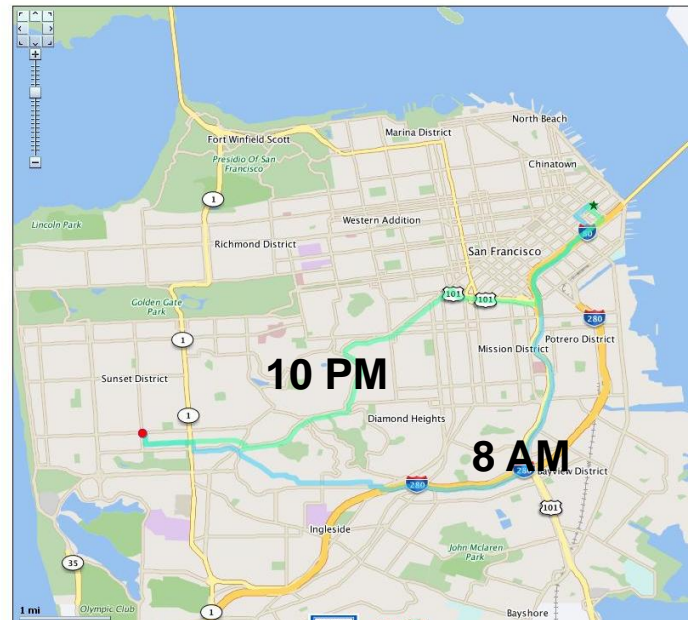
Analysis Result:

(199488837~199919135)

[cost:872.83101, 172 links]

Time to analyze the network: 0.436s.

Time to compute geometries: 0.039s.



Network Data Model Graph

Multi-Modal Routing

- Each mode (car, bus, rail, bike, etc) modeled as a separate network
- Single logical network represents all modes of transportation
- Transition nodes where networks meet
- NDM APIs can specify the modes
- Out of the box support for transit data published by transit authorities

Time to compute geonames: 2.4125.

Analysis Result:
From: 575456205
To: 575481535

Drive/Walk to
'CONNECTICUT AV and WYOMING AV'
(31 meters).

[1]
Board Route 227 (Inbound)
At 'CONNECTICUT AV and WYOMING AV'
Dep. Time : 10:10:42

Get down at 'NW CONNECTICUT AV and NW 20TH ST';

[2]
Transfer to Route 86
Board Route 86 (Outbound)
At 'NW CONNECTICUT AV and NW 20TH ST'
Dep. Time : 10:21:00

Get down at 'NW H ST and NW JACKSON PL';

[3]
Transfer to Route 75
Board Route 75 (Inbound)
At 'NW H ST and NW JACKSON PL'
Dep. Time : 10:32:42

Get down at 'SE INDEPENDENCE AV and SE 1ST ST';

[4]
Transfer to Route 131
Board Route 131 (Outbound)
At 'E CAPITOL ST and SE 1ST ST'
Dep. Time : 11:01:06

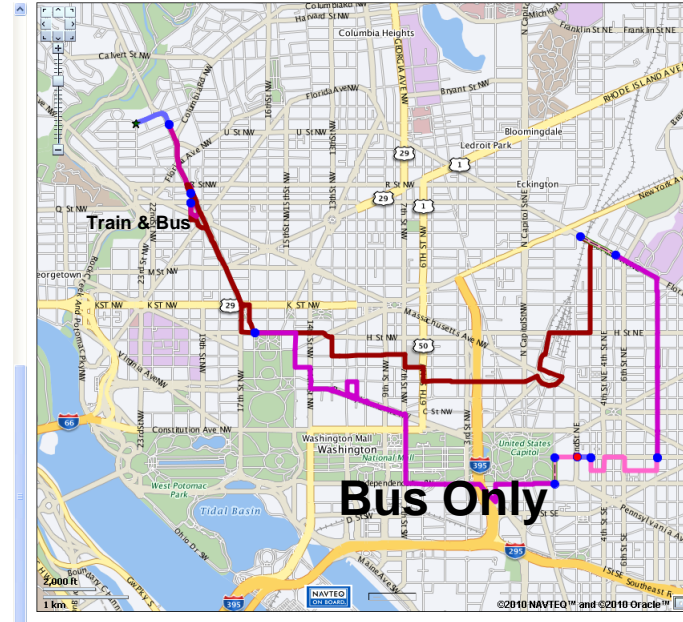
Get down at 'E CAPITOL ST and SE 3RD ST'
At 11:02:00

Drive/Walk from
'E CAPITOL ST and SE 3RD ST'
(0 meters) to destination.

Trip Travel Time: 51 minutes.

Number of Bus Routes-4
Number of Train Routes-0

Time to analyze the network: 0.914s.

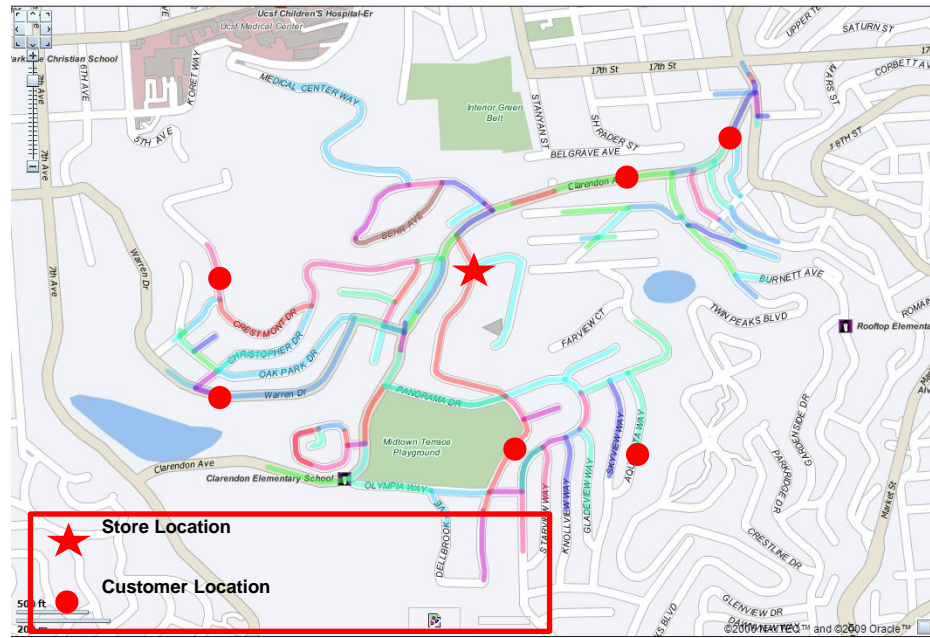


Network Data Model Graph

Large Scale Drive Time/Distance Analysis

Big Data Analysis

- Millions of customers, find closest store within a specified drive time
- Single database query to find closest store and drive time/distance for each customer
- Customers geocode as based on graph segment
- Network Buffer generates all possible paths

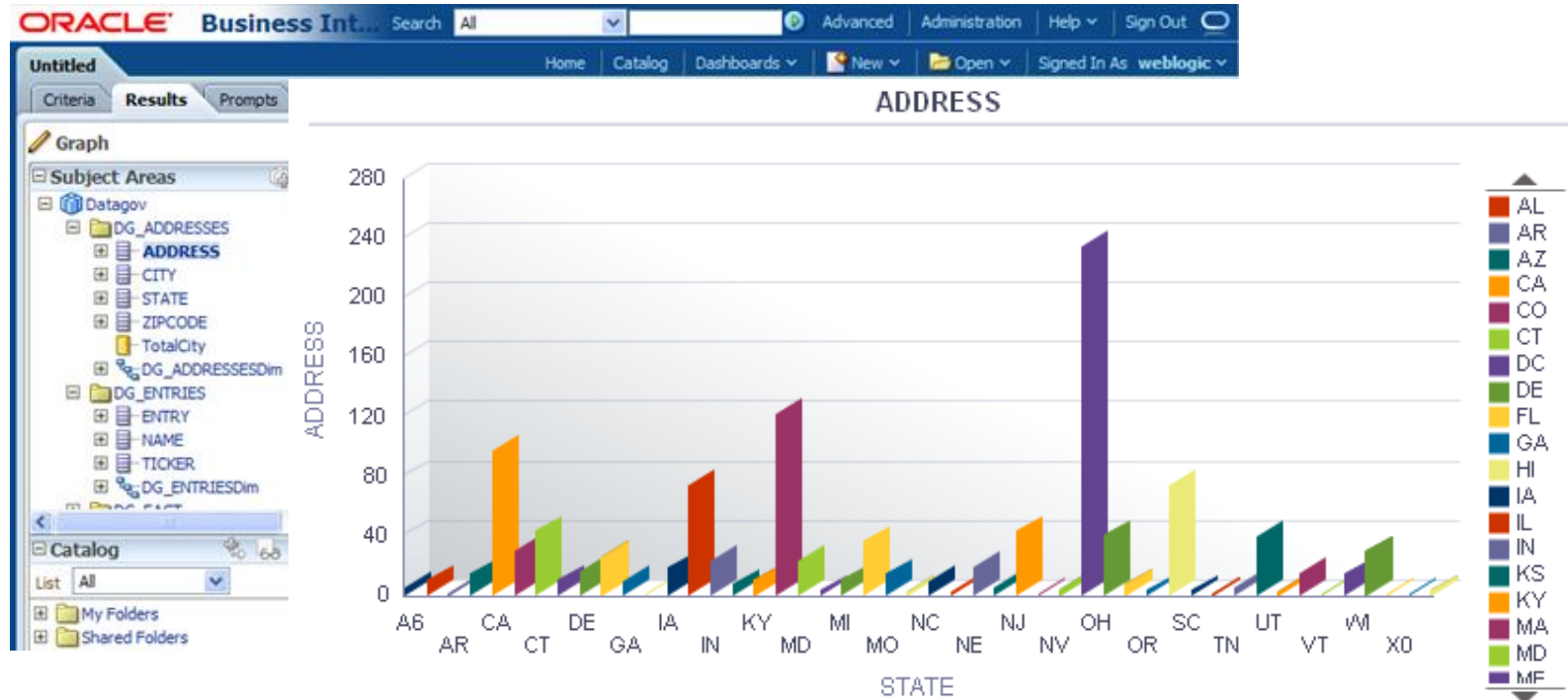


New functions in Oracle Database 12c

RDF Semantic Graph

- RDF views on relational tables
 - RDF views can be created on a set of relational tables and/or views
 - SPARQL queries access data from both a relational and RDF store
 - Allows filtering of data in a relational store based upon graph analysis
 - Support RDF view creation using
 - Direct Mapping: simple and straightforward to use
 - R2RML Mapping: customizations allowed

RDF Graph results with Oracle Business Intelligence SPARQL Gateway



Performance and In-Database Analysis

RDF Semantic Graph

Reasoning



Faster, more efficient, and secure reasoning engine

SPARQL 1.1



Richer query language with improved path analysis. Less application code.

GeoSPARQL



Query language for spatial “linked data.” Less application code.

**Named
Graphs**



Standard Mechanism to distinguish graphs models in large graphs.

Summary of New Graph Features

- Network Data Model graph
 - Real World Feature Modeling
 - Multimodal Routing, Temporal Modeling and Analysis
 - Large Scale Drive Time/Distance Analysis
- RDF Semantic Graph
 - RDF views on relational tables
 - SPARQL 1.1, GeoSPARQL, SPARQL Gateway
 - Enhanced Reasoning and Security
 - Named Graphs

Oracle Exadata

Spatial and Graph Resides in Oracle Database Kernel

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- Code resides in Database Address Space
- Spatial Index operations performed in Database SGA
- Spatial operators are parallel enabled by default and execute in Database Address Space for maximum scalability
- Spatial and Graph analysis and data models seamlessly exploit Database security, compression, partitioning services

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Oracle Exadata

Faster Index and Query Operations

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EXADATA



- Spatial operations are performed in Database System Global Area memory
- Spatial data warehouse performance increases of up to 100x faster
- Spatial Box and Distance queries up to 25x faster

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Extreme Compression for Point, Line and Polygon Data Sets

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EXADATA



- Point, Line and Polygon geometries can all benefit from EHCC
- Lines and Polygons, they must be stored inline (less than 4K in size).
- Options include:
 - COMPRESS FOR QUERY LOW
 - COMPRESS FOR QUERY HIGH
 - COMPRESS FOR ARCHIVE LOW
 - COMPRESS FOR ARCHIVE HIGH

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Oracle Exadata

Extreme Scalability for Millions of Spatial Objects

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EXADATA



- Millions of spatial objects evaluated in minutes
 - Point in polygon analysis
 - Polygon to polygon analysis
 - Deviation from route
 - Distance covered
- Millions of Spatial objects ingested in minutes
 - Weather readings
 - Traffic readings
 - Sensor readings

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Oracle Exadata

High Performance RDF Graph Workloads

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EXADATA



- RDF Semantic Graph is designed for the Exadata architecture
- 3x faster inferencing and querying
- Parallel load, inference and query
- Inferencing accelerated with Hybrid Columnar Compression
- Queries faster with OLTP index compression on B-tree indexes

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Oracle Exadata

Summary

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EXADATA



- Only Oracle Spatial and Graph is designed for the Exadata architecture
- Breaks new boundaries for ingesting spatial data
- Data warehouse spatial query performance up to 100x faster
- Spatial box and distance queries up to 25x faster
- Accelerated parallel, compressed RDF Graph workloads

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Oracle Spatial and Graph

Proven, industry-leading technology

Dramatically improved performance

Simpler, more scalable applications

Engineered for Exadata

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DATABASE



Plug into the **Cloud.**

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