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From Point Cloud to City Model – The 3D Data Management Lifecycle

GWF 2016 Workshop – 3DCityDB on Oracle

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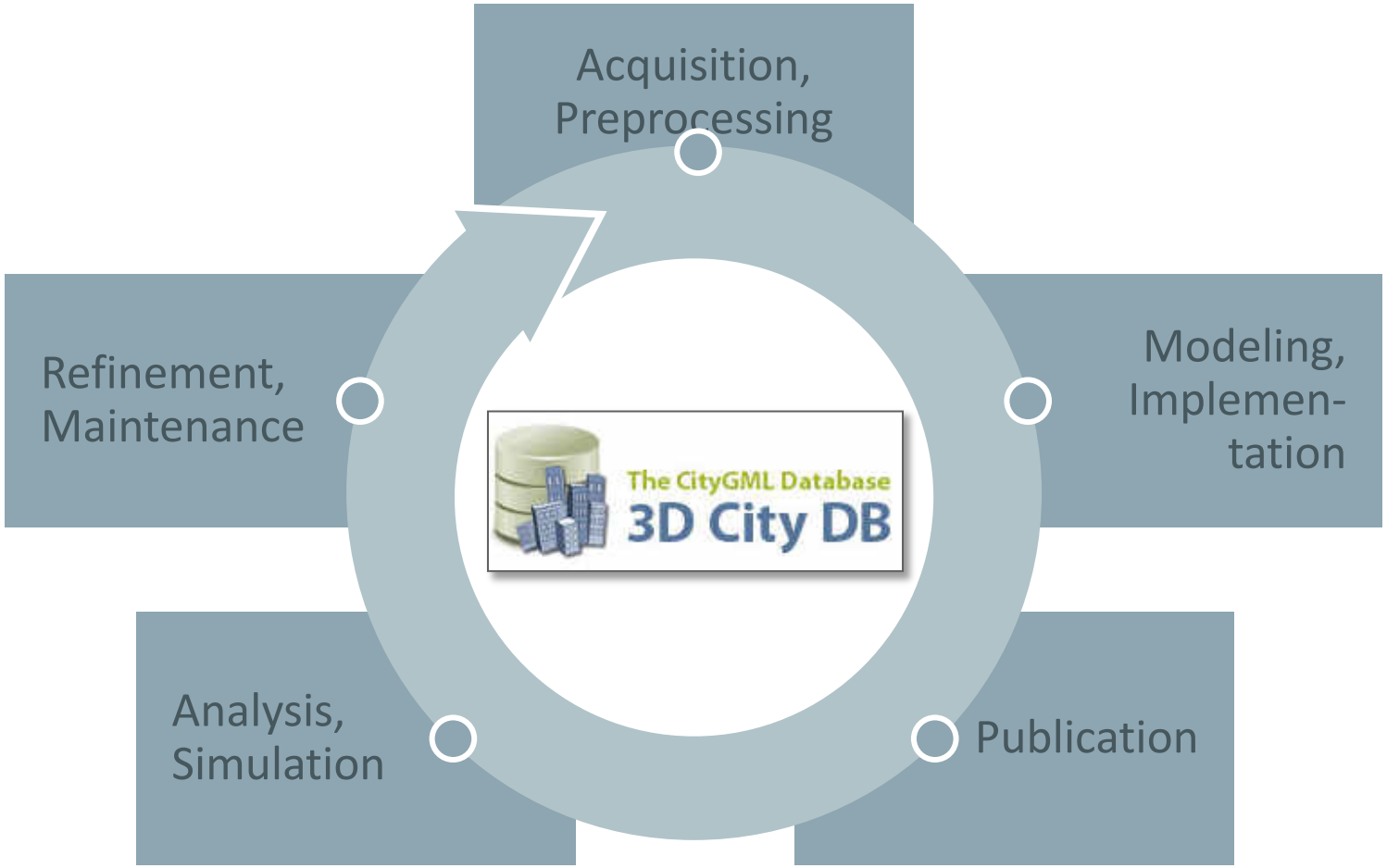
CityGML in Practice

Using 3DCityDB on Oracle for City Modeling



Agenda

- Hans Viehmann (Oracle)
  - From Point Cloud to City Model – The 3D Data Management Lifecycle
  - Data Conflation, Processing, Publishing
- Stephan Plabst (M.O.S.S.)
  - Simplifying the Management of your 3D Data with Automatic and Scalable Workflows
  - Modeling, Maintenance, Change Detection
- Lutz Ross (virtualcitySYSTEMS)
  - CityGML-based SDIs – Implementation requirements and examples
  - Best Practices and Visualization

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City Modeling

- Many business cases have become economically viable
  - Cost of 3D data collection has gone down significantly
- Leading to large scale projects, sometimes country-wide initiatives
  - Eg. in Poland, the Netherlands (3D Pilot NL, AHN-2), Germany (AdV), UK, Ireland, ...
  - Using LiDAR or Photogrammetry for data acquisition
- In Europe partly driven by EU mandates (eg. noise emission)
  - Requiring 3D data for simulation
- Lots of use cases, eg. in Smart Cities track
  - City and urban planning, citizen participation, city marketing, ...
  - Users in Local Government, Telco, Utilities, Public Transport, Public Safety, ...

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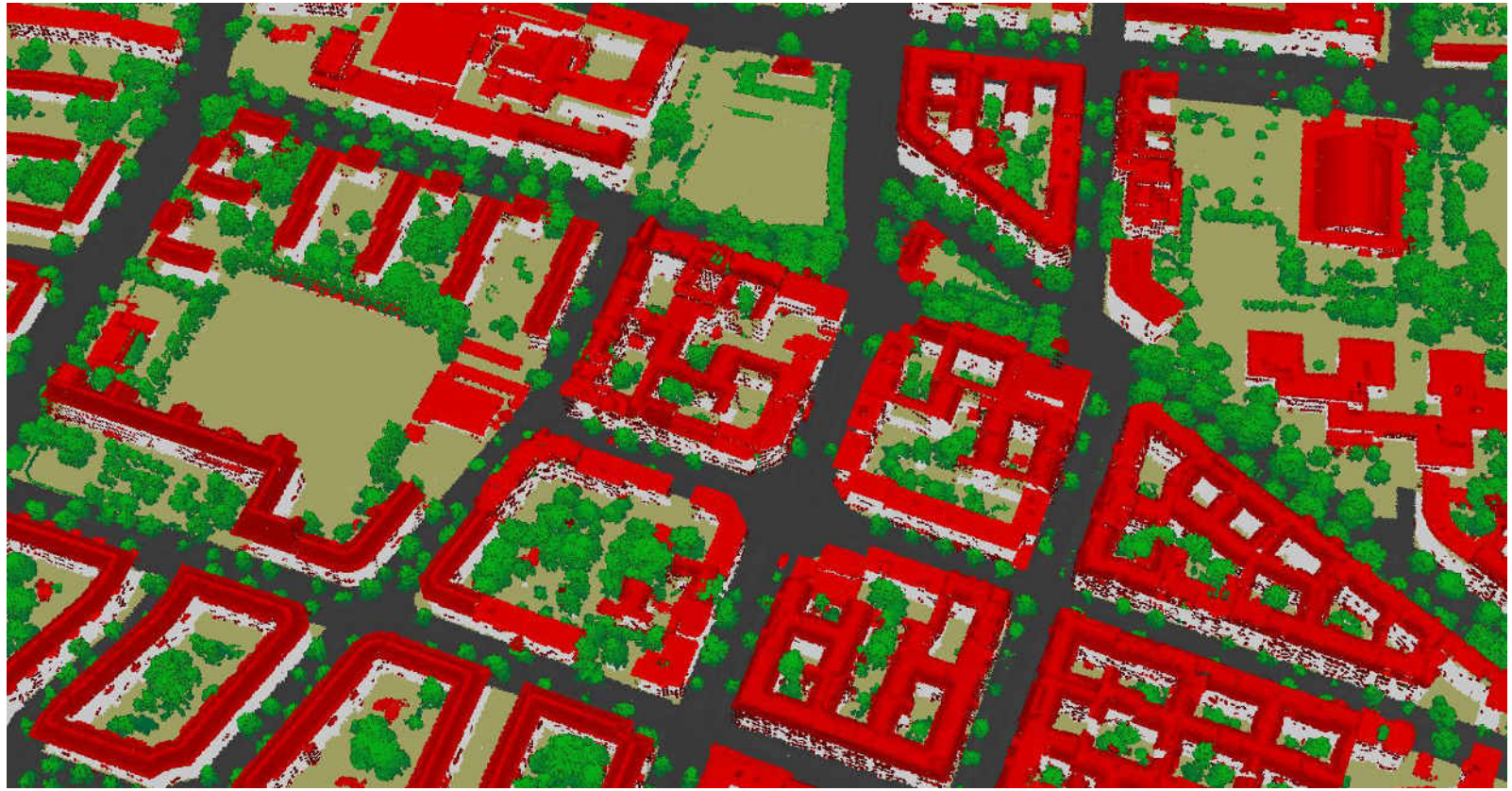
Visualization

Simple graphical representation – data, not information



Screenshot courtesy of Rico Richter, HPI

Modeling and CityGML

Using the data requires objects

- Modeling required for any kind of analysis beyond visualization
  - Associating objects with geometry, topology, semantics, appearance, ...
- CityGML is established standard for this purpose
  - Information model to represent relevant 3D urban objects
  - Defining classes and relations for these objects
  - XML-based format to exchange and store data (GML3-based application schema)
  - Standardized by OGC, currently in version 2.0.0
  - Can be used to derive logical data model in databases

3DCityDB

Open source data model - www.3dcitydb.org

- Semantically rich, hierarchically structured model
- Five different Levels of Detail (LODs), including textures and facades
- Representation of generic and prototypical 3D objects
- Free, also recursive aggregation of geo objects
- Complex digital terrain models (DTMs)
- Management of large aerial photographs using SDO_GEORASTER objects
- Version and history management
- Matching/merging of building features
- Works with Oracle Spatial and Graph 10gR2, 11g and 12c

City of Berlin – 3D City Model

Implemented on Oracle with 3DCityDB

- 550000 buildings, reconstructed from 2D cadastre and LIDAR data
- Textures extracted from oblique aerial photography
- 2012 Oracle Spatial Excellence Award

Images courtesy of: TU Berlin, Institute for Geodesy and Geoinformation

Why use a database here?

Requires a spatially enabled database

- Data integration with other sources
  - Online availability, including history and metadata
  - Geo-referenced imagery, existing 3D structures, attributes,...
- Fast access to arbitrary part of data set
  - For processing or visualization
- General benefits of mature DBMS
  - Information lifecycle management – data administration, tuning
  - Scaleability – multi-processor support, clustering, ...
  - Executing data-intense logic where the data resides

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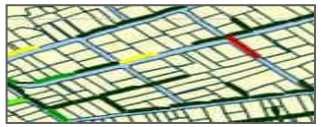
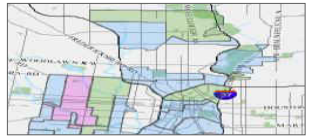
Oracle Database with Spatial and Graph Option

"Points"



"Lines"



"Polygons"

Web Services (OGC)

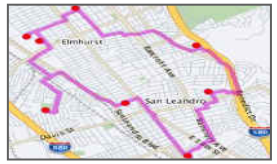
SPARQL End Point

Oracle Spatial and Graph

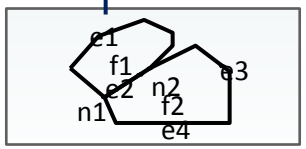
Geocoding, Routing

Inferencing

Rasters



Network Graphs



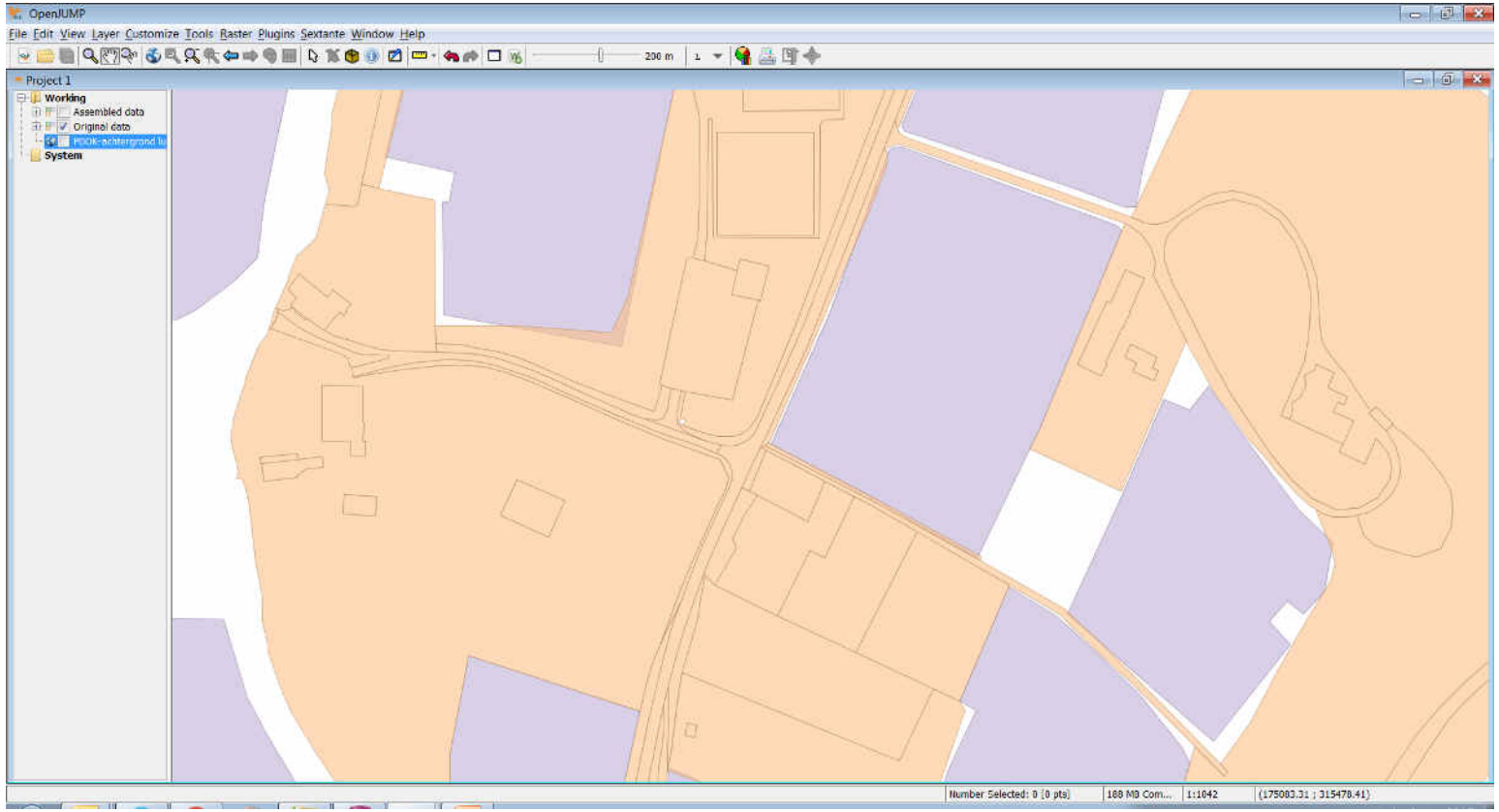
Topologies

RDF Semantic Graphs

3D

Spatial Processing in BGT BRAVO Project

Automating data conflation and quality assurance



Spatial Processing in BGT BRAVO Project

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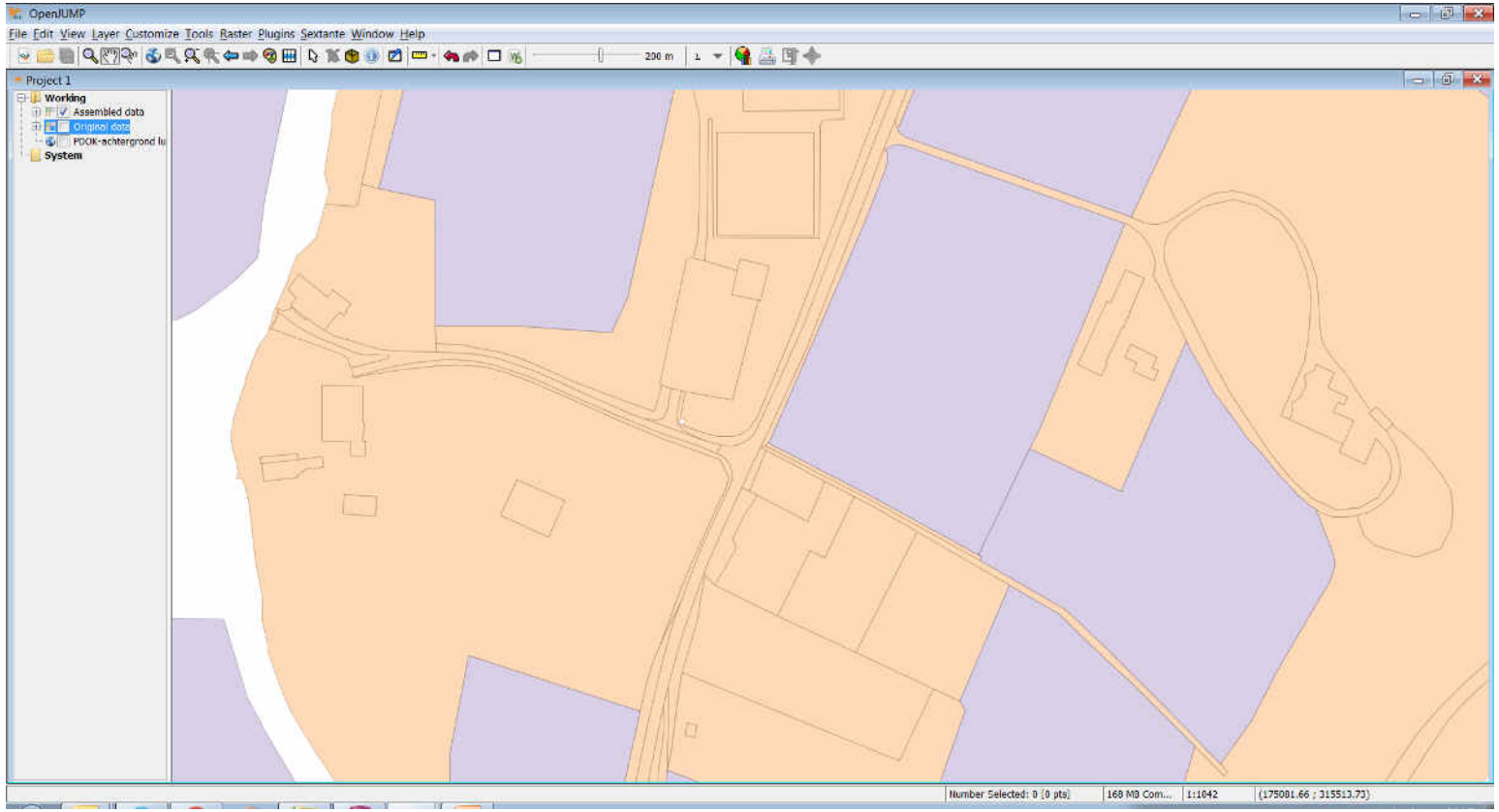
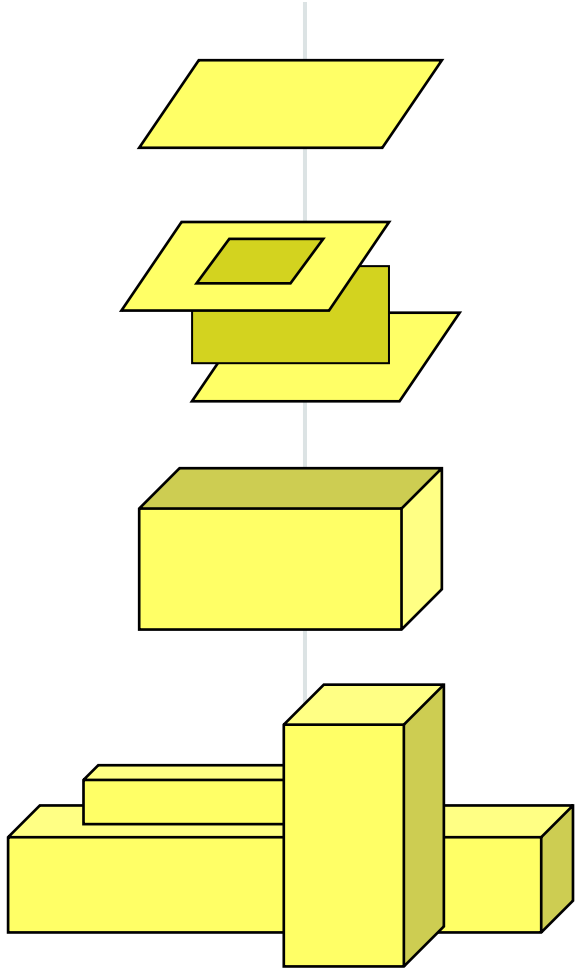
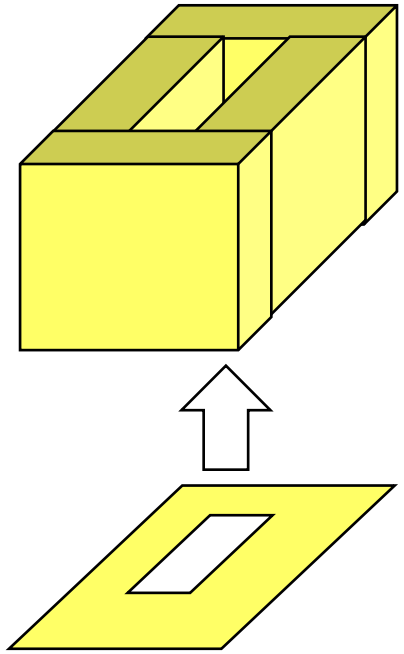


Creating a 3D model – elementary building blocks

- Simple Surfaces
  - Face = 3D Polygon
- Composite Surface
  - Multiple connected faces
- Simple Solid
  - Closed composite surface
- Composite Solid
  - Multiple connected simple solids



- Extrusion
  - Generating solids from 2D polygons



Other relevant database object types

- TINs (SDO_TIN)
  - Separating physical storage from logical structure to support huge datasets
  - Extraction, conversion to geometry
  - Compression for efficient storage
- Point Clouds (SDO_PC)
  - Separating physical storage from logical structure to support huge datasets
  - Extraction, conversion to geometry
  - Processing, eg. create TIN, generate contour lines
- Georeferenced Raster (SDO_GEORASTER)
  - Separating physical storage from logical structure to support huge datasets
  - Supporting any kind of gridded data
  - Ingesting lots of formats through GDAL
  - Image processing, mosaicking
  - Pyramiding for fast rendering
  - Raster algebra (for NDVI, TCT, or bespoke algorithms) and analytics

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Dutch eScience research project on Massive Point Clouds

Project Consortium, led by Peter v. Oosterom, TU Delft

- TU Delft
- NLeSC (Netherlands eScience Center)
- Oracle Corporation (NEDC)
- Rijkswaterstraat
- Fugro B.V.
- AHN-2 Dataset of the entire country
- 6 -10 pts/m^2 ➔ 640 billion pts
- 60,185 LAZ files, 987 GB in total, 11.64 TB uncompressed

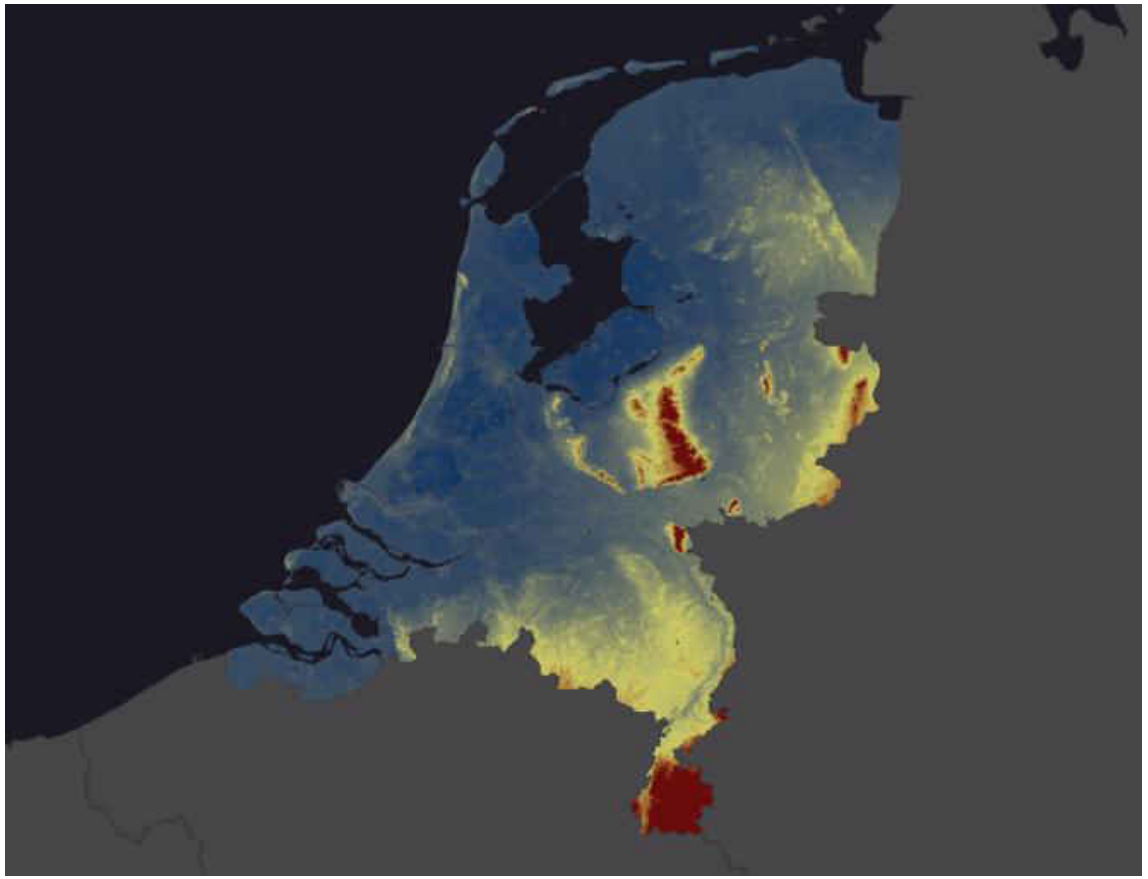

Image courtesy of: PDOK, NL

Scalability testing with AHN-2 dataset

Performance and best practices

- Testing on Oracle Engineered System (Exadata X4-2)
- Loading all 640bn points from LAZ files in 4:39h
- Using Hybrid Columnar Compression
  - Requires 2.24TB of storage in database, compared to 0.97TB in LAZ files or 12TB (uncompressed) LAS
- Massive parallelization of processing
- Even in single user database environment usually outperforms file system
- Available as Cloud Service

How can this be used?

- Derivation of 3D models
  - Classification, conflation with data from other sources
- Web-based or service-based rendering
  - Visual inspection, etc.
  - using the full resolution of the dataset or parts thereof (pyramiding)
- Large scale data dissemination
- In-database processing and analytics, specifically change detection
  - Change detection in multi-temporal point clouds
  - Particularly for buildings and vegetation

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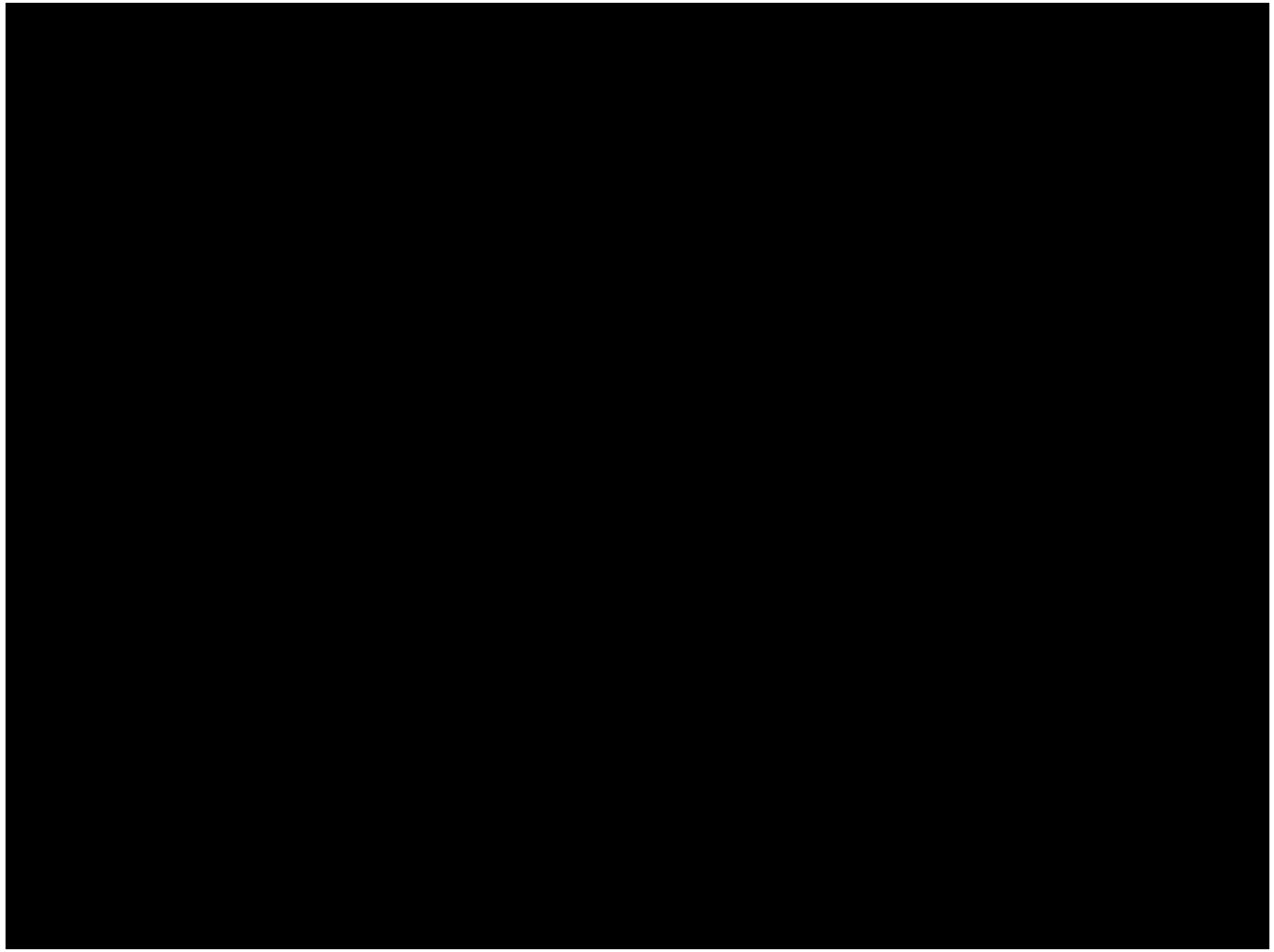
Visualization and interactive analysis



Publish KML in the XDB Repository

```
declare
  result boolean;
  kmldoc xmltype;
begin
  SELECT  xmlelement ( "kml",
            xmlattributes ('http://www.opengis.net/kml/2.2' as "xmlns"),
            xmlelement ("Document",
              xmlelement ("Style",
                xmlattributes('BuildingStyle' as "id"),
                xmlelement ("LineStyle", xmlelement ("width",'1'),xmlelement ("color",'ff0000ff')),
                xmlelement ("PolyStyle", xmlelement ("color", '7d0000ff'))
              ),
              xmlagg (
                xmlelement ("Placemark",
                  xmlelement ("name", 'Building '|| gmlid),
                  xmlelement ("styleUrl", '#BuildingStyle'),
                  xmltype (
                    sdo_util.to_kmlgeometry (snap_to_ground (sdo_cs.transform(geom,4327),0))
                  )
                )
              )
            )
          )
  INTO kmldoc
  FROM buildings_ext;
  result := dbms_xdb.createResource ('/public/Buildings/buildings_ext.kml', kmldoc);
end;
/
```

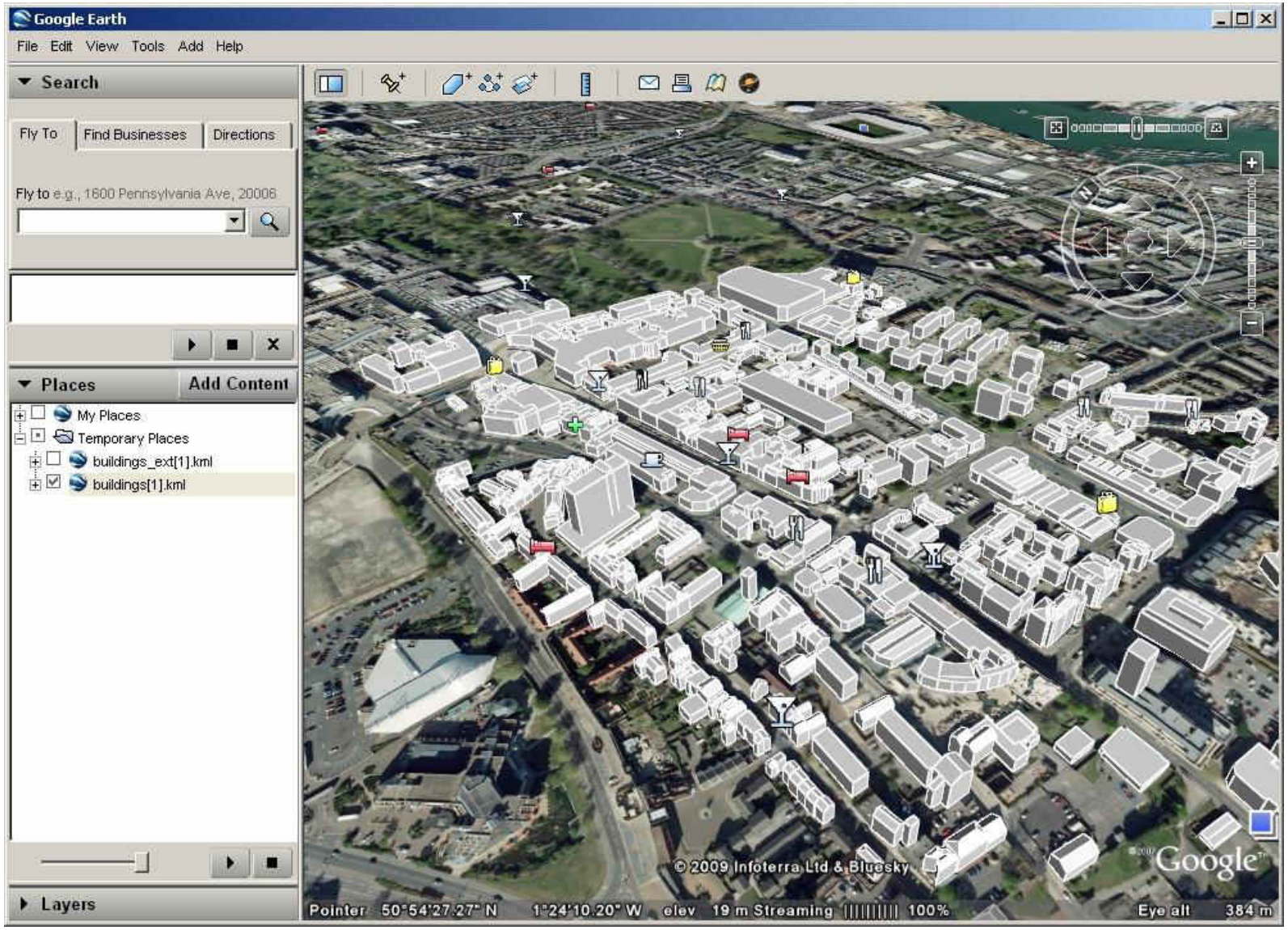
Style definition

Use the style

Fix Z values

Transform to WGS84

Render in KML Viewer

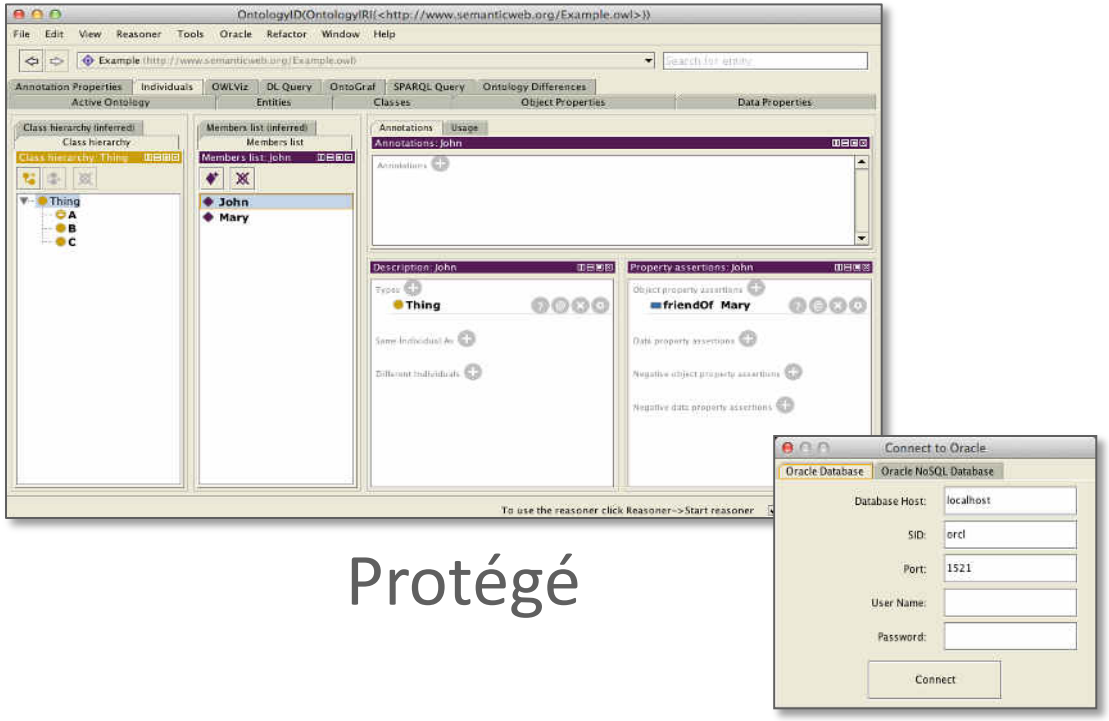


Publish as Linked Data

Using RDF Graph support in Oracle Spatial and Graph

- Support for RDF, OWL, SPARQL, … is integral part of database
- Using database as triple store
- Allowing RDF views on relational tables
- Standards-compliant SPARQL endpoint, GeoSPARQL support
- SPARQL queries in SQL possible
- Inferencing engine inside database

Semantic Modeling



Protégé

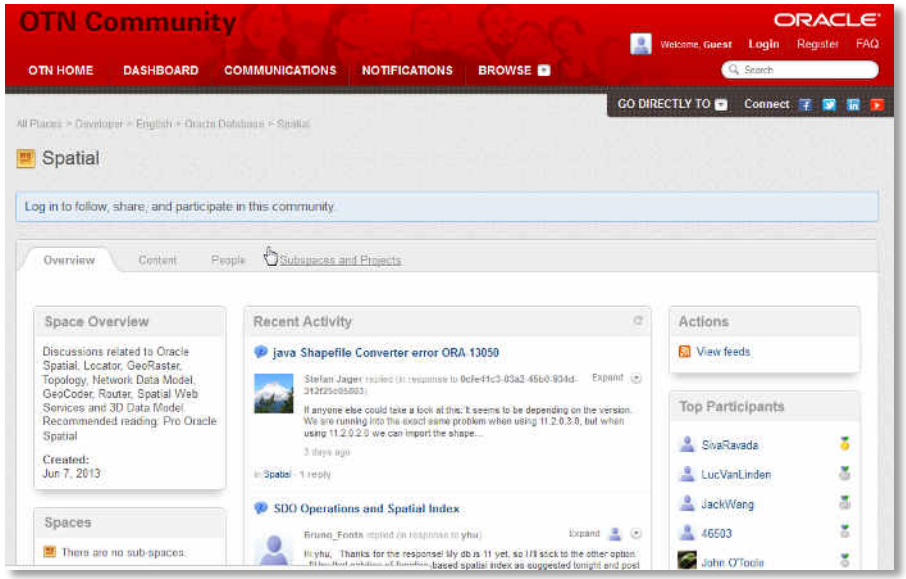
Summary

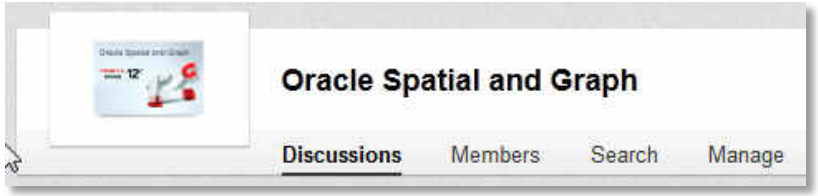
Managing 3D Data in 3DCityDB on Oracle

- „live“ access to 3D data for visualization and analysis
- Integrated management of all kinds of 2D and 3D data
  - Single source of truth for geospatial and associated attribute data
- Large scale „in-situ“ processing
  - Object recognition, data analysis, ...
- Management and publishing of data and metadata
  - Making data useable through open standards
- Taking advantage of cost saving database functionality
  - Compression, information lifecycle management, ...

More resources

- Further information on oracle.com
  - www.oracle.com/goto/spatial
- Blogs
  - https://blogs.oracle.com/oraclespatial
- Developer forums on OTN
  - https://community.oracle.com/community/database/oracle-database-options/spatial
- LinkedIn community
  - „Oracle Spatial and Graph“ group
- Google+ community
  - „Oracle Spatial and Graph SIG“





Integrated Cloud

Applications & Platform Services

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