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May 2012

Oracle Spatial User Conference

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Oracle Spatial User Conference

May 23, 2012

Ronald Reagan Building and International Trade Center

Washington, DC USA

Javier Herreruela

Institute for Geodesy and Geoinformation Science

Technical University of Berlin

Joint work with T.H.Kolbe, C.Nagel, G.König, A.Lorenz, B.Naderi

Deploying 3D City Models for Urban and Metropolitan Planning

Program Agenda

- CityGML Short Introduction
- 3D City DB Overview, CityGML Support
- 3D City DB KML/COLLADA Export
- 3D City DB in Action

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CityGML Short Introduction

Modeling Urban Spaces

Application-independent Geospatial Information Model
for virtual 3D city and landscape models

- CityGML defines an **ontology of the urban space**
  - Facilitates urban information modeling
  - Comprises **different thematic areas** (buildings, water, terrain, etc.)
- **Adopted international OGC standard** since 08/2008
- **CityGML represents**
  - 3D geometry, 3D topology, semantics and appearance
  - in 5 discrete scales (Levels of Detail, LOD)

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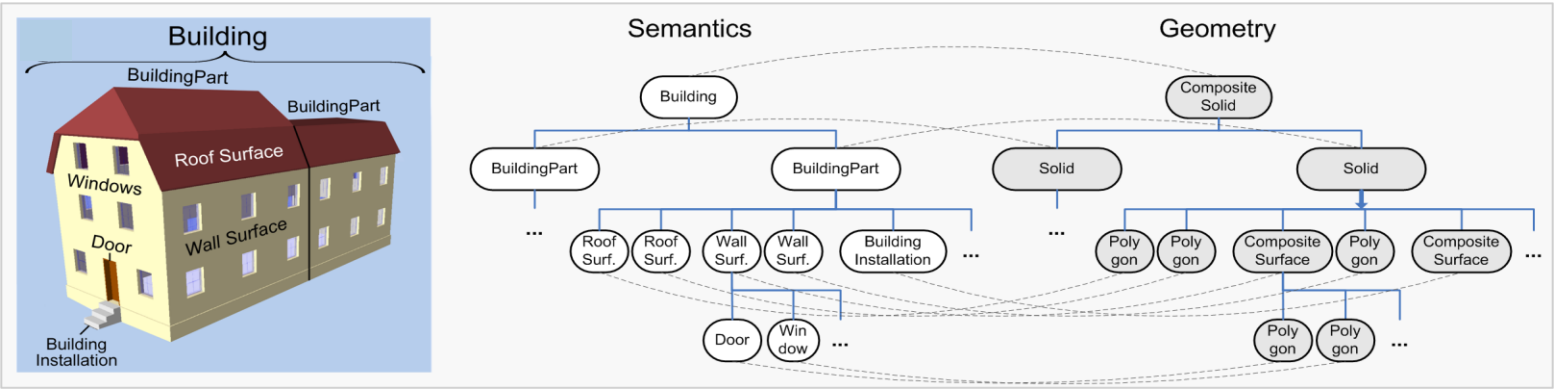
CityGML Short Introduction

CityGML vs. Graphics Formats



- **Hierarchically structured feature model**
- **Spatio-semantic coherence**
  - Geometric entities know **WHAT** they are
  - Semantic entities know **WHERE** they are and their spatial extents
- **Facilitates sophisticated semantic and spatial analyses**

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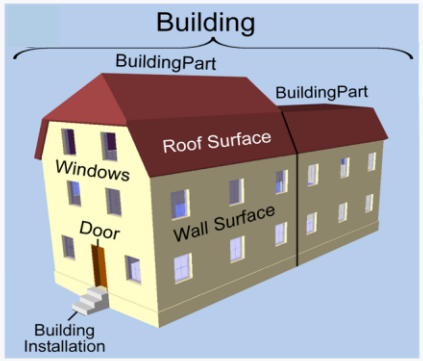
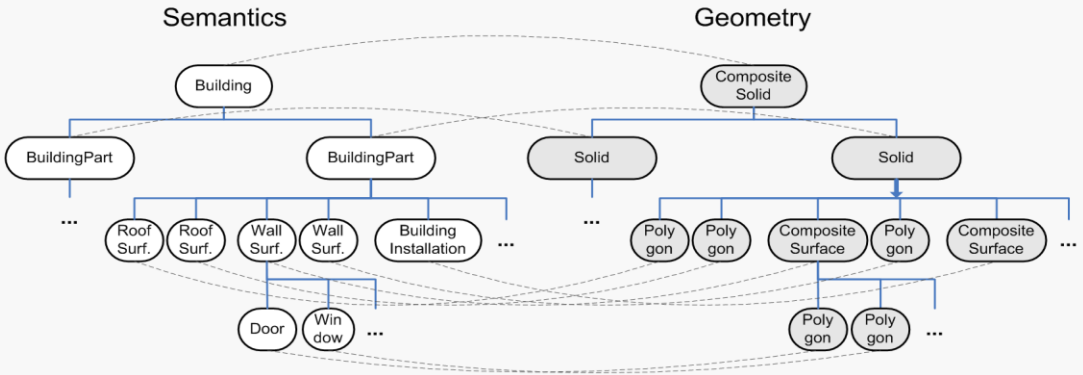
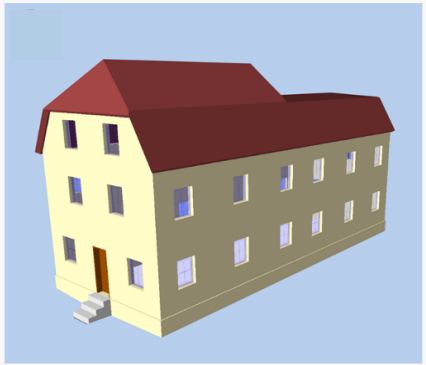
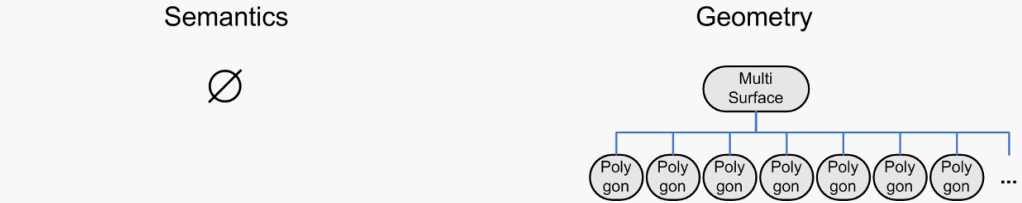




CityGML: Complex semantic objects with structured geometry





KML, X3D, VRML, etc.: No or little semantics, just (unstructured) geometry

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3D City DB Overview, CityGML Support

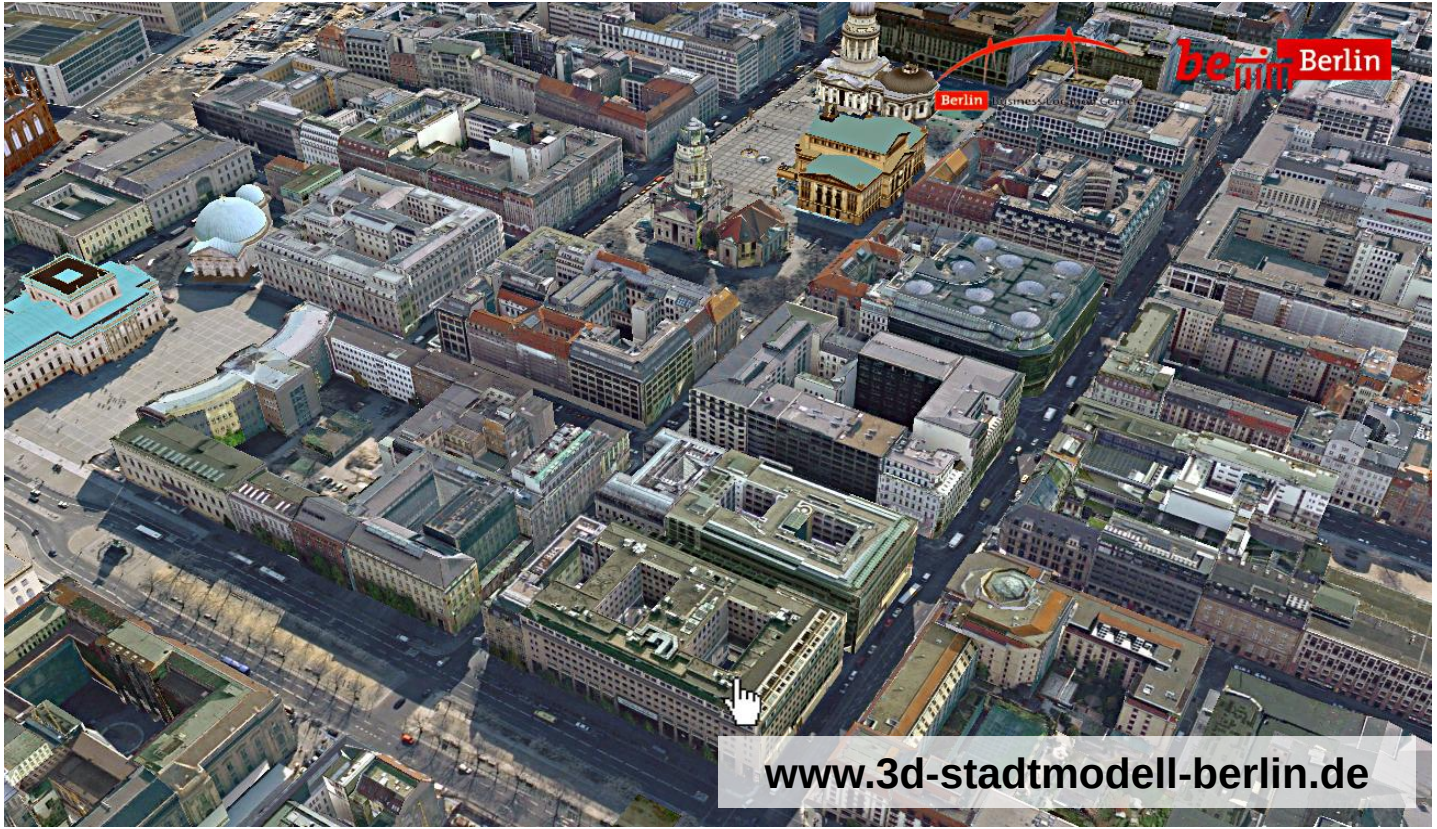
Background: 3D City model of Berlin

550,000 buildings, reconstructed from 2D-cadastre and LIDAR-data

Textures automatically extracted from oblique aerial images

Semantic information based on cadastre data

Model structured according to CityGML



3D City DB Overview, CityGML Support

Motivation for a 3D geo database in Berlin

- **Repository for the official 3D city model**
  - Complete representation of city topography and landscape
  - Data from various sources (cadastre, architecture, utility networks, etc.)

- **Usage of 3D city model for applications like**
  - City and Urban Planning
  - Energy assessment for smart cities
  - Political Issues and Consulting, Civic Participation

- **Basis for the Berlin 3D Spatial Data Infrastructure**
  - Access through standardized OGC Web Services, Google Earth (KML), online streaming

3D City DB Overview, CityGML Support

Tools - www.3dcitydb.net

3DCityDB v2 is a **free and Open Source 3D geo database** to store, represent, and manage virtual 3D city models

3D City Database

- Semantically rich, hierarchically structured model
- Five different Levels of Detail (LODs)
- Appearance data in addition to flexible 3D geometries
- Complex digital terrain models (DTMs)
- Management of large aerial photographs
- Version and history management
- Matching/merging of building features
- Works with Oracle Spatial 10g R2, 11g R1, and 11g R2

3D City DB Importer/Exporter

- Full support for CityGML 1.0 and 0.4.0
- Exports of KML/COLLADA models
- Generic KML information balloons
- Reading/writing CityGML instance documents of arbitrary file size
- Multithreaded programming facilitating high-performance CityGML processing
- Resolving of forward and backwards XLinks
- User-defined Coordinate Reference Systems
- Coordinate transformations for CityGML exports

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3D City DB Overview, CityGML Support

Where is it already in operation?

3D City DB used in production systems

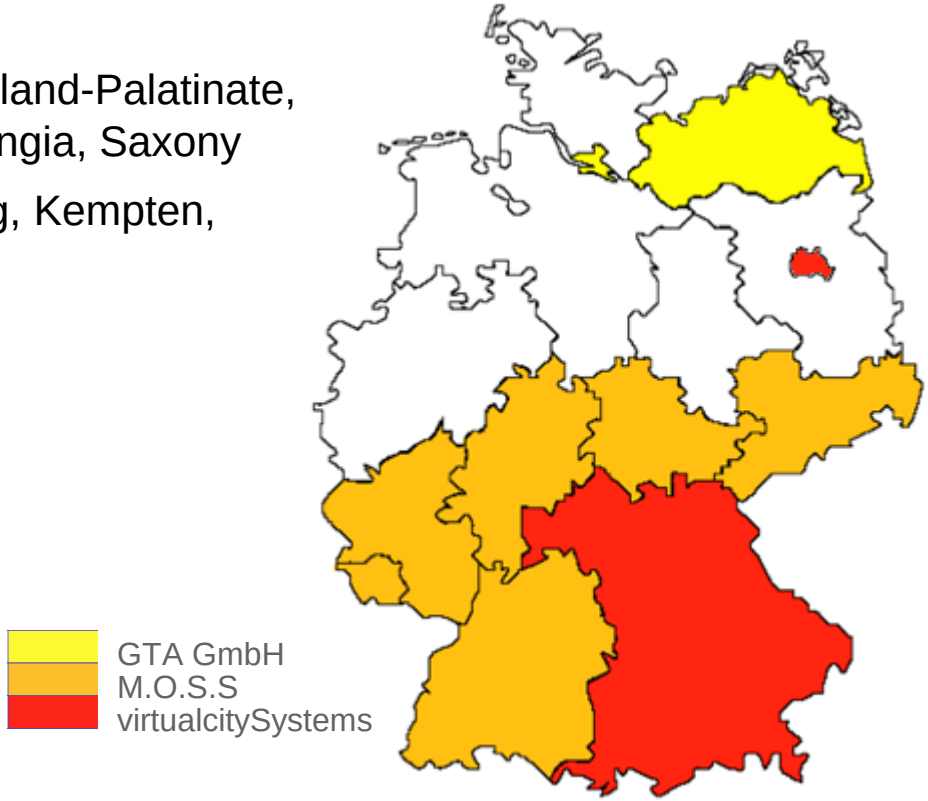
- State Mapping Agencies in Saarland, Rheinland-Palatinate, Baden-Württemberg, Hesse, Bavaria, Thuringia, Saxony
- Cities: Berlin, Potsdam, München, Nürnberg, Kempten, Zürich (Switzerland)

Used in products by commercial partners

- virtualcitySYSTEMS
- M.O.S.S
- Autodesk LandXPlorer

Trial period

- SOM Chicago, TU Delft, Autodesk Paris, Rotterdam



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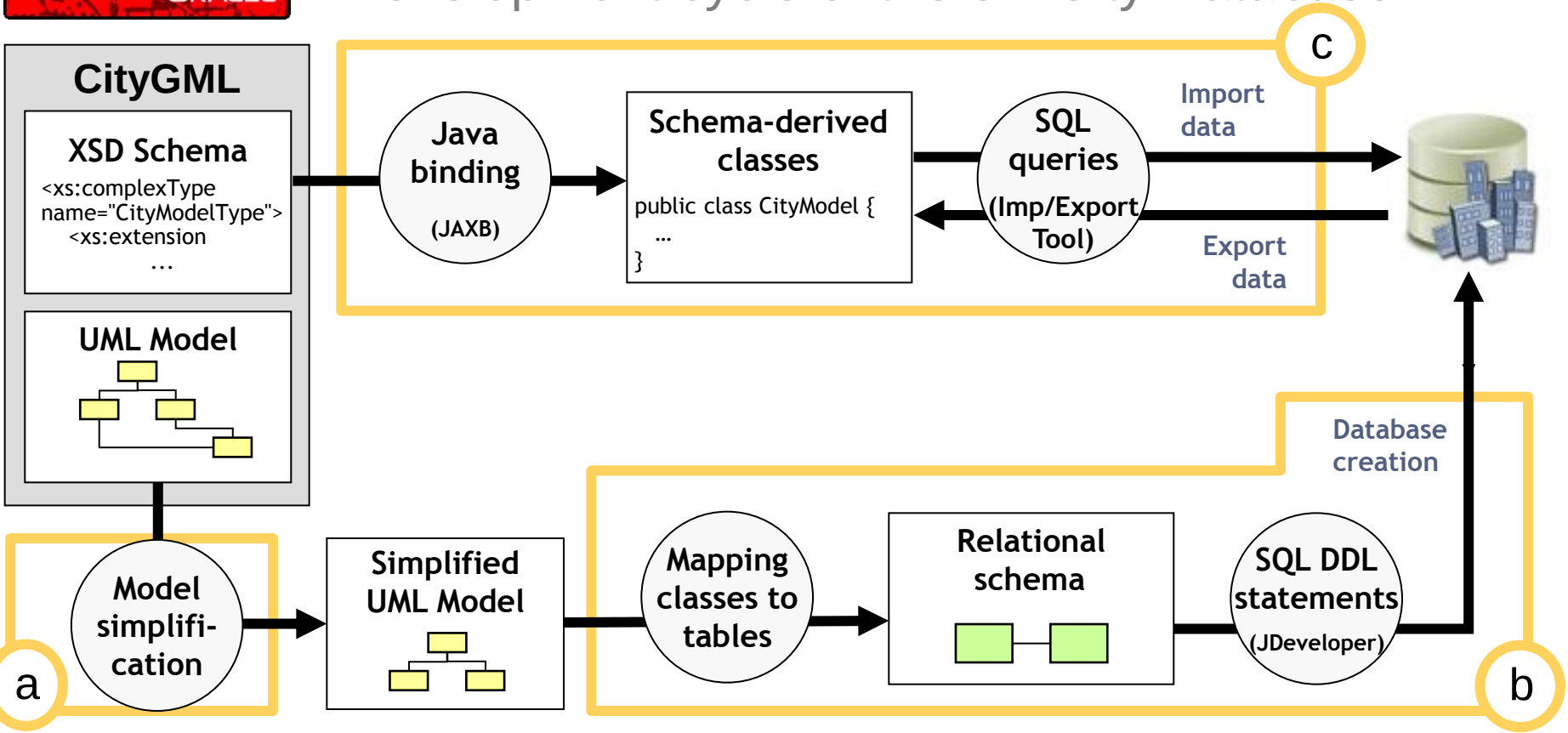
3D City DB Overview, CityGML Support

Development cycle of the 3D City Database



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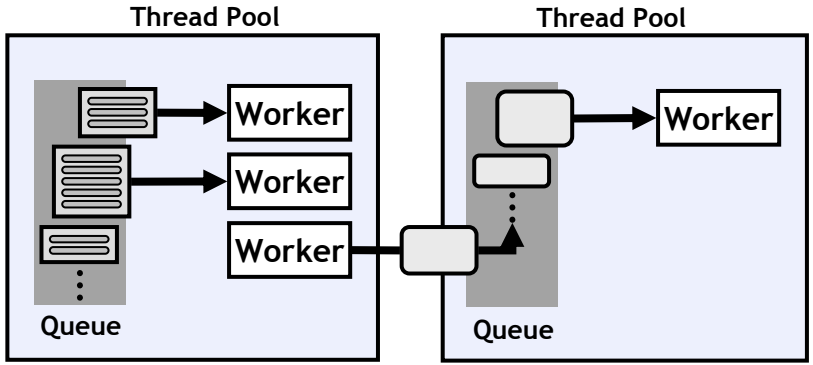
3D City DB Overview, CityGML Support

Main features

- **Standalone Java client for import/export of CityGML models**
  - Support for CityGML files of arbitrary file size (>> 4GB)
  - High-performance CityGML processing through multithreading
  - Resolving of forward and backwards Xlinks
  - Support for different CRSs and coordinate transformations (based on Oracle Spatial functionality)
  - **Exporting data as KML/COLLADA visualization models**
- **Open Source and released under the terms of the LGPLv3**



3D City DB Overview, CityGML Support

Some performance facts

- **3DCityDB server:** 4x Intel® Xeon® QuadCore, RedHat EL 5, 56GB RAM, 4 SAS disks (146GB), 16 SSD RAID array (á 64GB), Oracle 10G R2 (default installation)
- **Berlin 3D City Model**
  - 534,357 buildings in LOD2 / LOD3 (file size: 11GB)
  - 2,109,496 thematic boundary surfaces (roof, wall, ground)
  - 9,083,266 surface geometries
  - 5,202,499 individual textures associated with geometries (202 MB)

Import and export times		
Import with textures (11000 tiled files)	9 h 30 min	77 feature/sec
Import w/o texture (1 file)	16 min	2754 feature/sec
Export with textures (11GB + 202MB)	28 min	1574 feature/sec
Export w/o textures (7.9GB)	5 min 20 sec	8262 feature/sec

3D City DB Overview, CityGML Support

Some performance facts

- **3DCityDB server:** 4x Intel® Xeon® QuadCore, RedHat EL 5, 56GB RAM, 4 SAS disks (146GB), 16 SSD RAID array (á 64GB), Oracle 10G R2 (default installation)
- **Cologne / Leverkusen 3D City Model**
  - 1,055,951 buildings in LOD1 (no textures, single file size: 7.8GB)
  - 11,511,040 surface geometries
  - 1,056,797 generic attributes

Import and export times		
Import (1 file)	25 min	704 feature/sec
Export (7.8GB)	5 min 10 sec	3406 feature/sec

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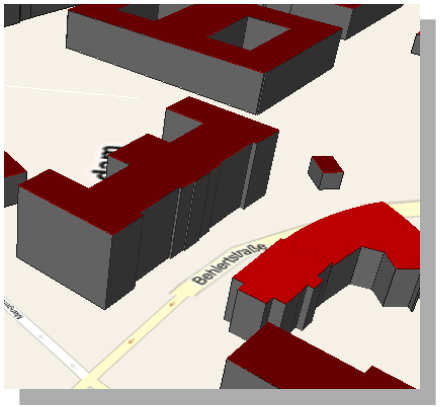
3D City DB KML/COLLADA Export

3D Visualisation of CityGML Models

- **One** 3D City Model
  - may comprise (or link) thematic data from different applications
  - can be stored and exchanged as one CityGML dataset

KML / COLLADA



KML

KML / COLLADA

3D City DB KML/COLLADA Export

Different Display Styles

Footprint

Extruded

Geometry

COLLADA

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3D City DB KML/COLLADA Export

Multiple Styles for Visual Levels-of-Detail

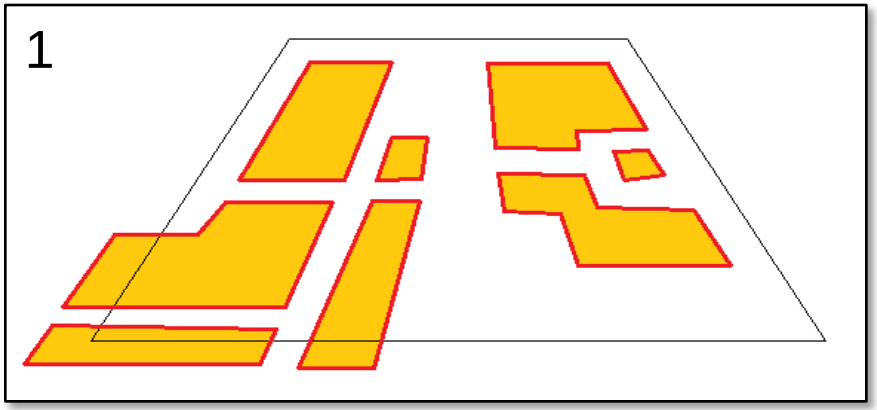
3D City DB KML/COLLADA Export

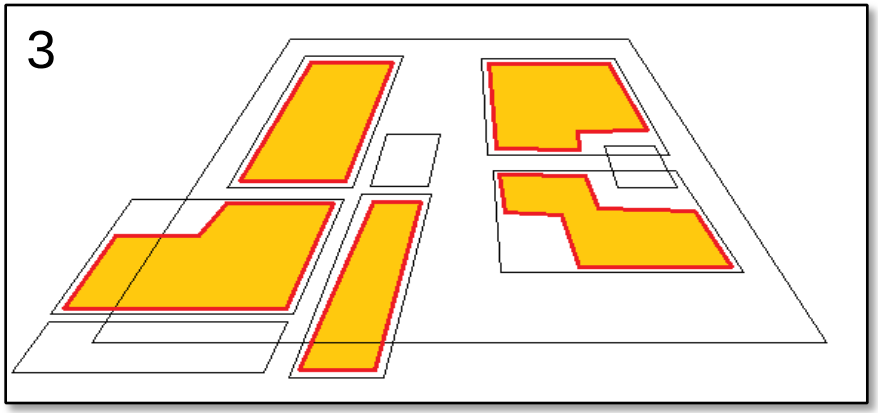
Tiling strategies

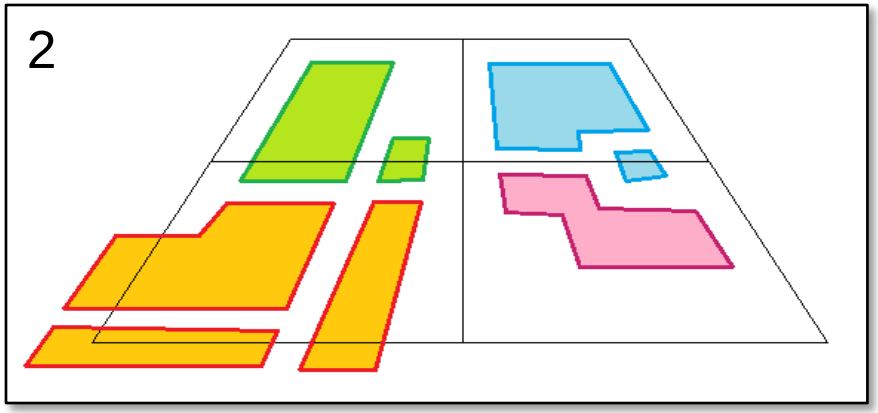
1. No tiling

2. Automatic (fixed tile size) or manual (rows, columns) tiling

3. Each CityObject in its own tile; this mode can be combined with any of the above







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3D City DB KML/COLLADA Export

3D Object Interaction and Information

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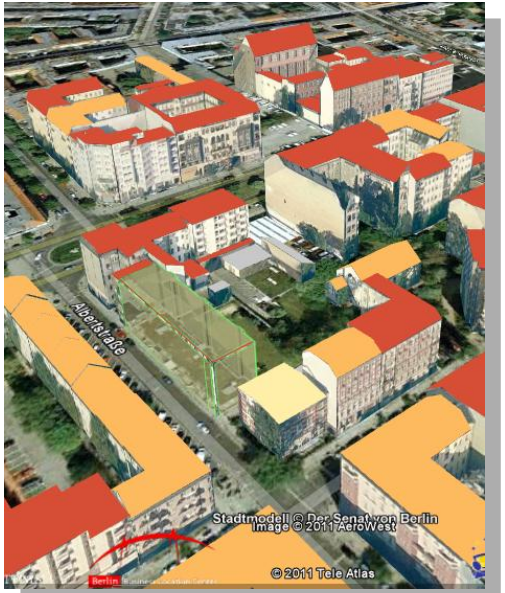
3D City DB KML/COLLADA Export

Application Specific Portrayal

- Example: Solar Atlas Berlin

Semantic information (here: estimated solar energy production) is used both to cartographically style the visualization and to fill the „information balloons“



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3D City DB in Action

New Application: Energy Atlas Berlin

Heat emission

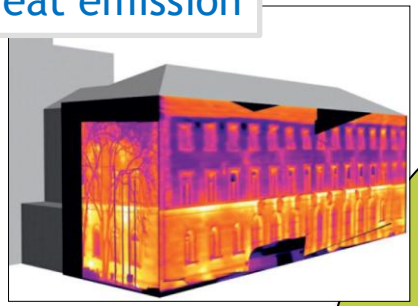
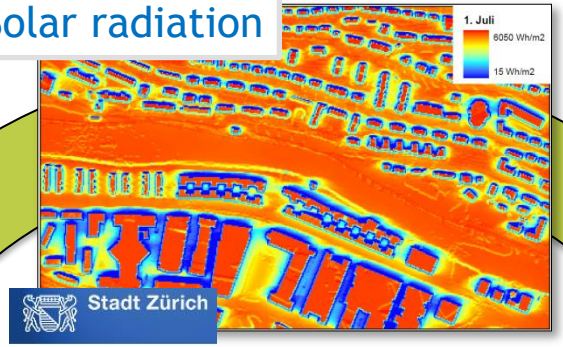
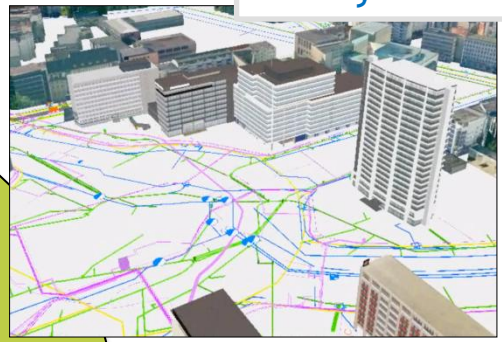


Image: Hoegner / Stilla, TU München

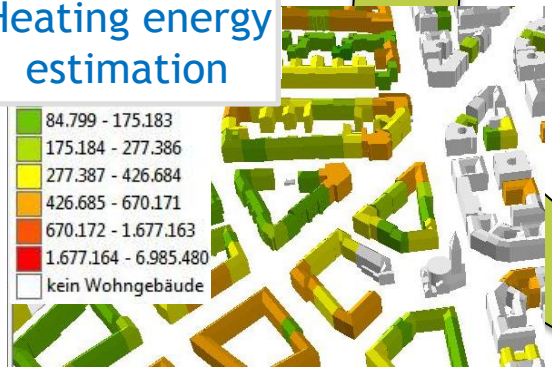
Solar radiation



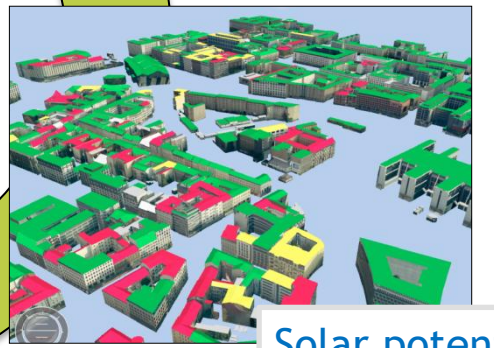
Utility network



Heating energy estimation



The CityGML Database
3D City DB



Solar potential

3D City DB - Summary

What is available?

http://www.3dcitydb.net

Open Source under LGPLv3

- **3D City Database (current version 2.0.6)**
  - Oracle SQL scripts and PL/SQL functions
  - Comprehensive documentation
- **3D City Database Import/Export Tool (current version 1.4)**
  - Executable Java binaries, complete source code, comprehensive documentation
  - Supports CityGML (input/output) and KML/COLLADA (output)

The 3D City DB is in practical use in many places all over Europe. In production environments, research institutes, educational centers and at the core of new innovative projects like the Energy Atlas Berlin

D E M O N S T R A T I O N

Energy Atlas Berlin

Q&A