Technische Universität Berlin
Institut für Geodäsie und Geoinformationstechnik

Section V

Extending CityGML and Application Examples

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EduServ6 Course on CityGML

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Overview

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  - CityGML Overview and Status
  - OGC Geography Markup Language (GML)
- Section II
  - Further GML Concepts and Application Modelling
- Section III – CityGML Details, Part 1
- Section IV – CityGML Details, Part 2
- Section V
  - Extending CityGML
  - Application Examples
- Section VI
  - Relations to Other Standards

Extending CityGML

Extending CityGML

1. Generic Attributes & *GenericCityObjects*

- every ***CityObject*** can have an arbitrary number of **extra attributes**
  - allows to extend objects like Buildings, Roads, etc. without the need of new application schemas
- **GenericCityObjects** can have arbitrary geometries (and generic attributes) for every LOD
- “extension during runtime“

2. Application Domain Extensions (ADE)

- extra XML schemas referring to the CityGML XML schema (defined by **information communities**)
- extensions to be **formally specified in XML schema**

Generic CityObjects and Attributes

- Explicitly modeled feature types have the advantage of well-defined object semantics, attributes, and relations
  - basis for semantic interoperability between different actors
- However, often concrete models comprise additional **attributes or features not covered by the model**
- Incorporation of **generic CityObjects and attributes**
  - **every CityObject** can have an **arbitrary number of** additional **generic attributes** (string, int, real, date, URI)
  - **GenericCityObject** is subclass of CityObject
  - arbitrary GML3 geometry for each LOD
- shall only be used, if there is no appropriate concept provided by CityGML (problematic wrt. semantic interop.)

Example for Generic Attributes

```
<Building gml:id="Building0815">
    <!-- other properties of feature type "Building" -->

    <stringAttribute name="BuildingOwner">
        <value>Mr. Smith</value>
    </stringAttribute>

    <doubleAttribute name="Value">
        <value>3500000</value>
    </stringAttribute>

    <!-- further properties of feature type "Building" -->
</Building>
```

- Available data types:
  integer, real (double), string, date, URI

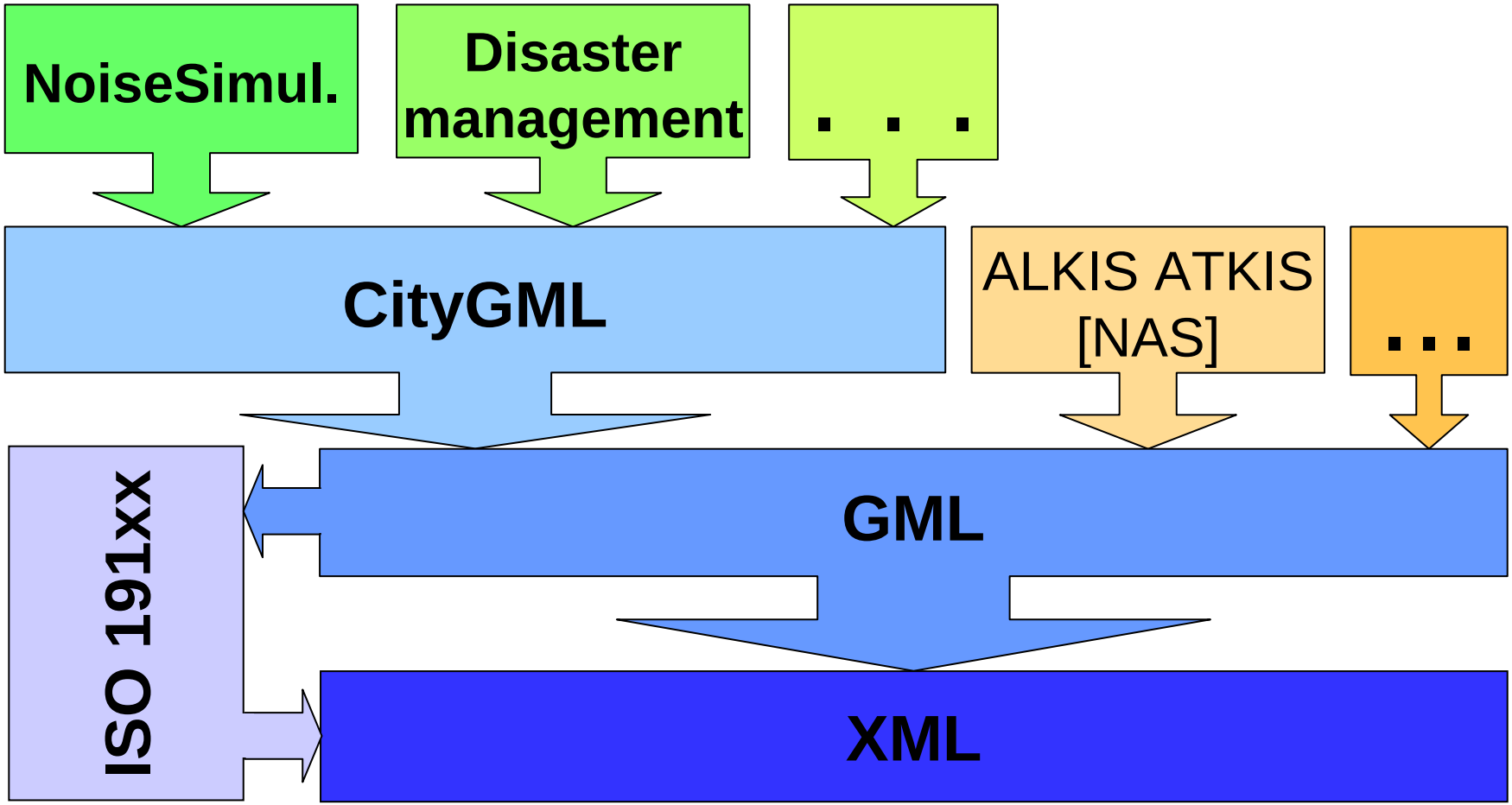
3D Information Communities

Extending CityGML
for specific application domains

Application Specific Extensions to CityGML

- CityGML should be considered a **base information model** for virtual 3D city models
- **But:** Specific applications need specific extra information
  - typically in close interaction with CityGML base information
- Examples
  - **Environmental simulations** like noise immission mapping need information about noise absorption of surfaces
  - **Cultural heritage** needs to augment objects by their heritage and history, and has to consider the development along time
  - **Utility networks** need to represent pipes, pipe tunnels, connectors, transforming devices

Application Domain Extensions (ADE)



Extension Considerations (I)

- **Information Communities** should be able to define extensions on their own
  - they must be able to associate new attributes to concrete CityGML feature types
  - formal definition of new properties / feature types in XML schema
  - similar situation to the specification of GML application schemas
- Different extensions should be usable **simultaneously**
  - e.g. CityGML Building features extended both by properties from real estate and noise pollution simulation
  - Requires **combinable application schemas**
- What about non-schema aware CityGML readers?

Extension Considerations (II)

Generally two types of domain specific extensions:

- **Extension of existing CityGML feature types** by
  - additional spatial and non-spatial attributes
  - additional relations / associations
- **Definition of new feature types**
  - preferably based on CityGML abstract base class *CityObject*
- Both are typically covered by the subclassing / inheritance mechanism of XML schema
  - *Create subclass of a CityGML feature type and add new properties to this class*

Typical Extension Approach

- create a **new feature type** by deriving the feature type from an (abstract) CityGML feature type like e.g. _*CityObject*, or
- **extend an instantiable feature type** by deriving a subtype from the concrete CityGML feature type and add new properties to this class
  - the extended CityGML class has to receive a new element name like *BuildingWithNoiseProperties*
  - **Problem: how to combine this with other extensions?**
  - **Problem: non-schema aware readers are not able to detect that a <BuildingWithNoiseProperties> is basically a <Building> element with some extra properties**

Extension of the CityGML XML Schema declarations:

```
<xsd:complexType name="Building" …>
      ……
      <xsd:element ref="_GenericApplicationPropertyOfBuilding"
                   minOccurs="0" maxOccurs="unbounded"/>
      ……
</xsd:complexType>

<xs:element name="_GenericApplicationPropertyOfBuilding"
             abstract="true" type="xs:anyType"/>
```

… will allow to inject further XML structures into CityGML feature types at a later point in time (hooks for ADEs).

- one hook for each CityGML feature type

Application Domain Extensions (ADE)

Declaration of application domain specific attributes for existing CityGML features (e.g. Building, XML schema)**:**

```
<xsd:element
        name="NoiseReflection"
        type="xsd:string"
        substitutionGroup=
                "citygml:_GenericApplicationPropertyOfBuilding">
</xsd:element>

<xsd:element
        name="BuildingHabitants"
        type="xsd:positiveInteger"
        substitutionGroup=
                "citygml:_GenericApplicationPropertyOfBuilding">
</xsd:element>
```

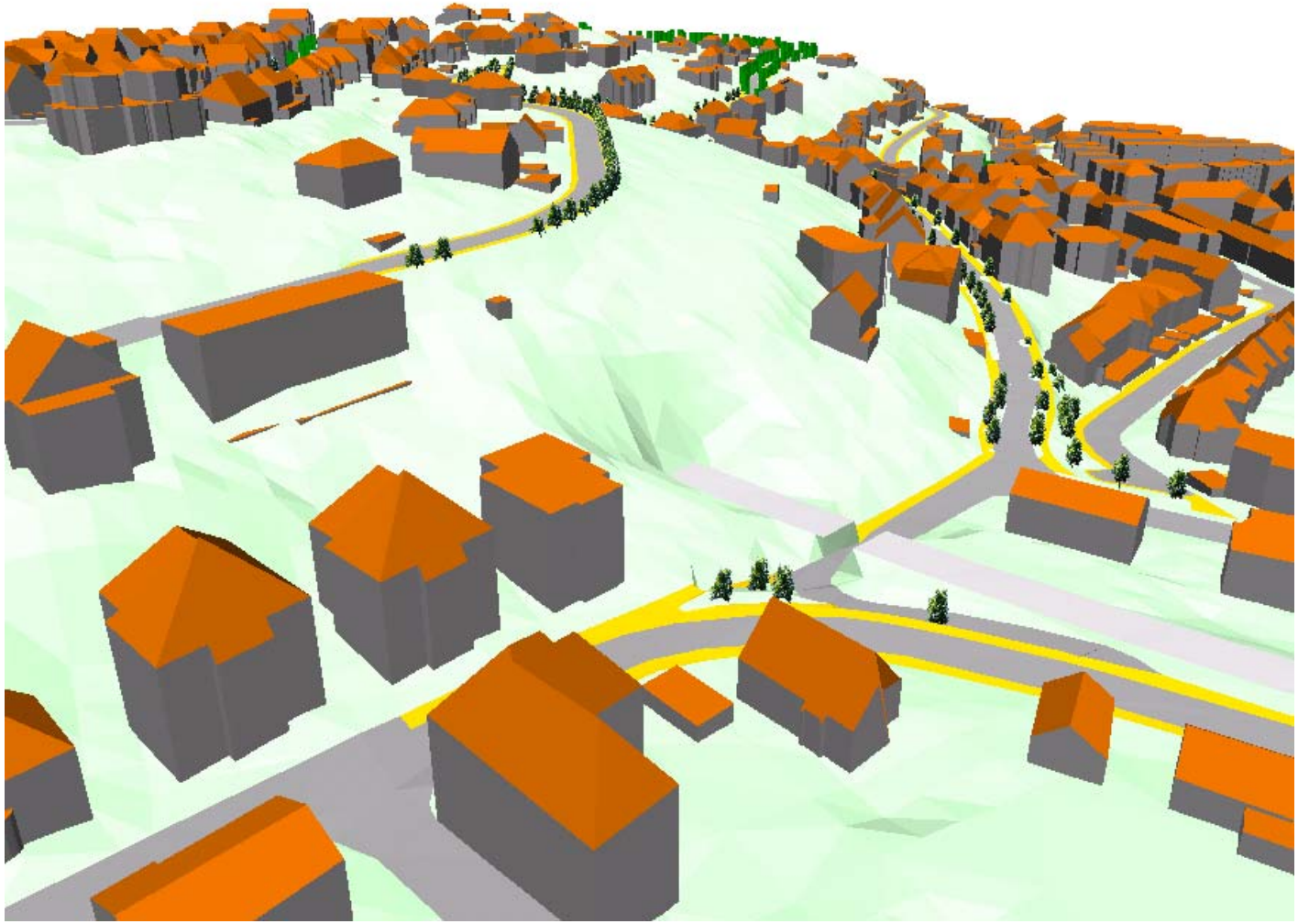
Application Domain Extensions (ADE)

Example for a CityGML **Building feature with** application specific **extra information** (qualified by a namespace):

```
<Building>
        <function>1000</function>
        ……
        <noise:NoiseReflection>12</noise:BuildingReflection>
        <noise:BuildingHabitants>8</noise:BuildingHabitants>
        ……
        <lod2Solid> ……  </lod2Solid>
</Building>
```

Application Examples

The Official 3D City Model of Stuttgart



Screenshot of administration system (SupportGIS)

LOD2

- Objects have full thematic Information
- texture acquisition ongoing

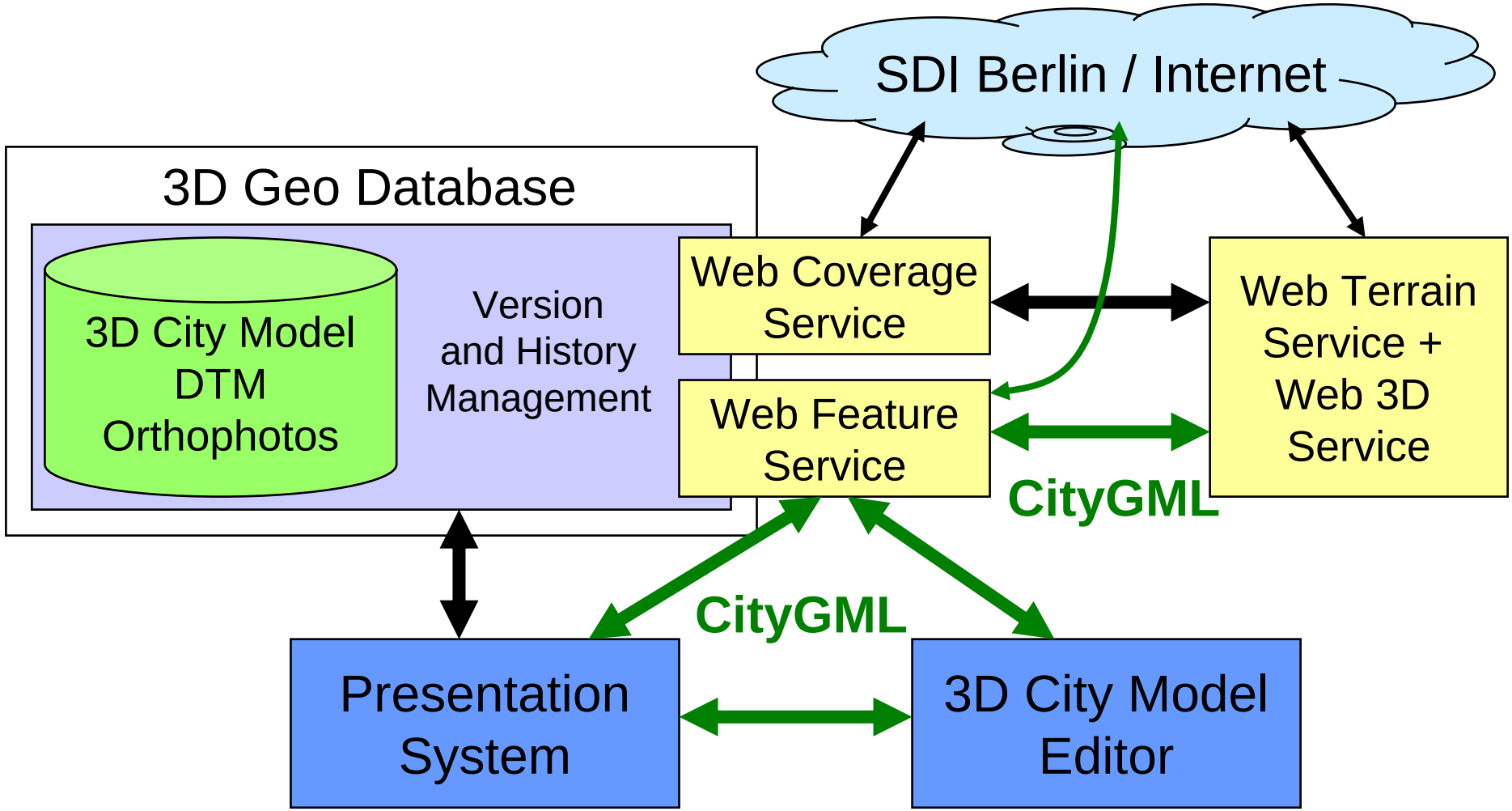
The Official 3D City Model of Berlin

www.3d-stadtmodell-berlin.de

3D visualization is the result of a portrayaling of Berlin‘s 3D city model

(modeled according to CityGML)

Berlin 3D: Realization with OGC Web Services



Application of CityGML for Noise Mapping

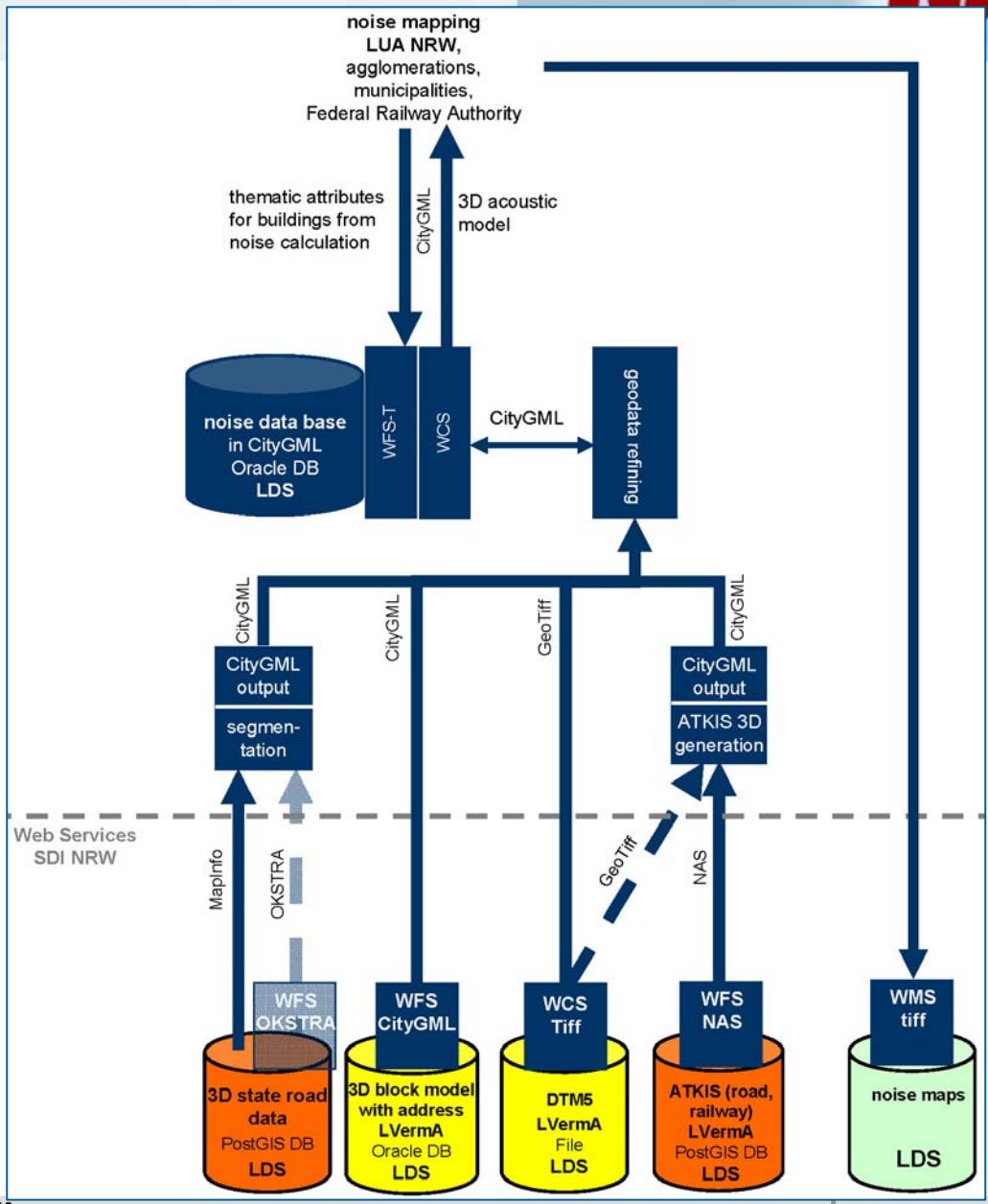
CityGML is applied in an ongoing project in Germany:

- Computation of **noise pollution maps** in the state North Rhine-Westphalia (18 million citizens)
- **Background: Environmental Noise Directive** from the European Commission
- Spatial Data Infrastructure uses following Web Services: WFS, WMS; Data formats: CityGML, GeoTIFF
- **Estimated savings** (wrt. proprietary systems): **>10 Mio €**
- Extension of CityGML by noise relevant attributes and features: **CityGML Noise ADE**

Noise Mapping: SDI Service Architecture

Project partners

- Department of Geoinformation Uni Bonn: project management & scientific consulting
- LVermA NRW: generation and continuation of state geobasic data (3D block models, DTM5, ATKIS data)
- Straßen.NRW: generation and continuation of 3D state road data
- LDS NRW: provider of geodata and web services
- LUA NRW: noise calculation, generation of noise maps
- lat/lon GmbH: WFS-T 3D block models in CityGML, WCS DTM5 in GeoTiff
- Interactive Instruments GmbH: WFS ATKIS data in CityGML, Service 3D state road data in CityGML
- Stapelfeldt GmbH: geodata refining for noise calculation purpose
- Zerna GmbH: contract management
- Institute for Geodesy and Geoinformation Science, TU Berlin: CityGML consulting



Employed 3D Geodata

3D building models (block models LOD1 in CityGML format) and thematic attributes (e.g. reflection, habitants)

- for 18 million citizens in the state North-Rhine Westphalia, Germany

Digital Terrain Model DTM5 (10x10m raster data in GeoTiff format)

ATKIS road and railway data (output as AAA/NAS [Germany's National Topography Standard based on GML3] and converted on-the-fly to 3D in CityGML format)

3D state road data (in CityGML format) and thematic attributes (e.g. traffic flow, portion of heavy vehicle, speed limit, road surface material, width of carriageway, road gradient)

3D noise barriers and thematic attributes (e.g. reflection)

Industrial activity sites and thematic attributes

Airports and thematic attributes

Municipal road and railway data

Employed Standards

CityGML-Version 0.4.0 OGC Best Practice Paper

- plus CityGML Noise ADE (application domain extension)

OGC Web Feature Service Implementation Specification 1.1.0.

OGC Web Coverage Service Implementation Specification 1.0.0

OGC Web Map Service Implementation Specification 1.1.1

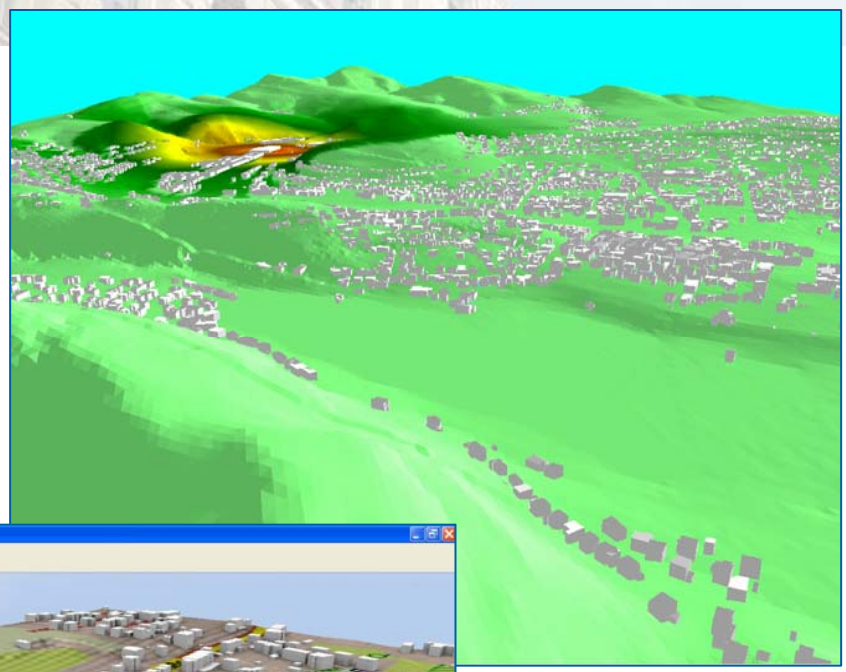
OGC Geography Markup Language (GML) Implementation Specification 3.1.1

GeoTIFF Format Specification 1.8.2

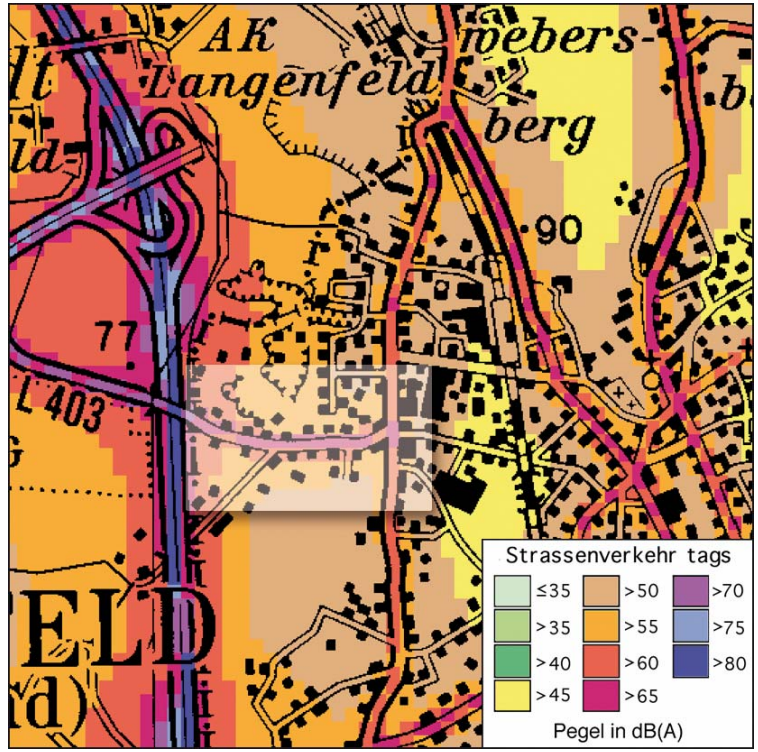
Illustration of Noise Pollution Mapping

3D block model in CityGML from WFS-T

DTM 10m grid in GeoTiff from WCS



noise immission simulation



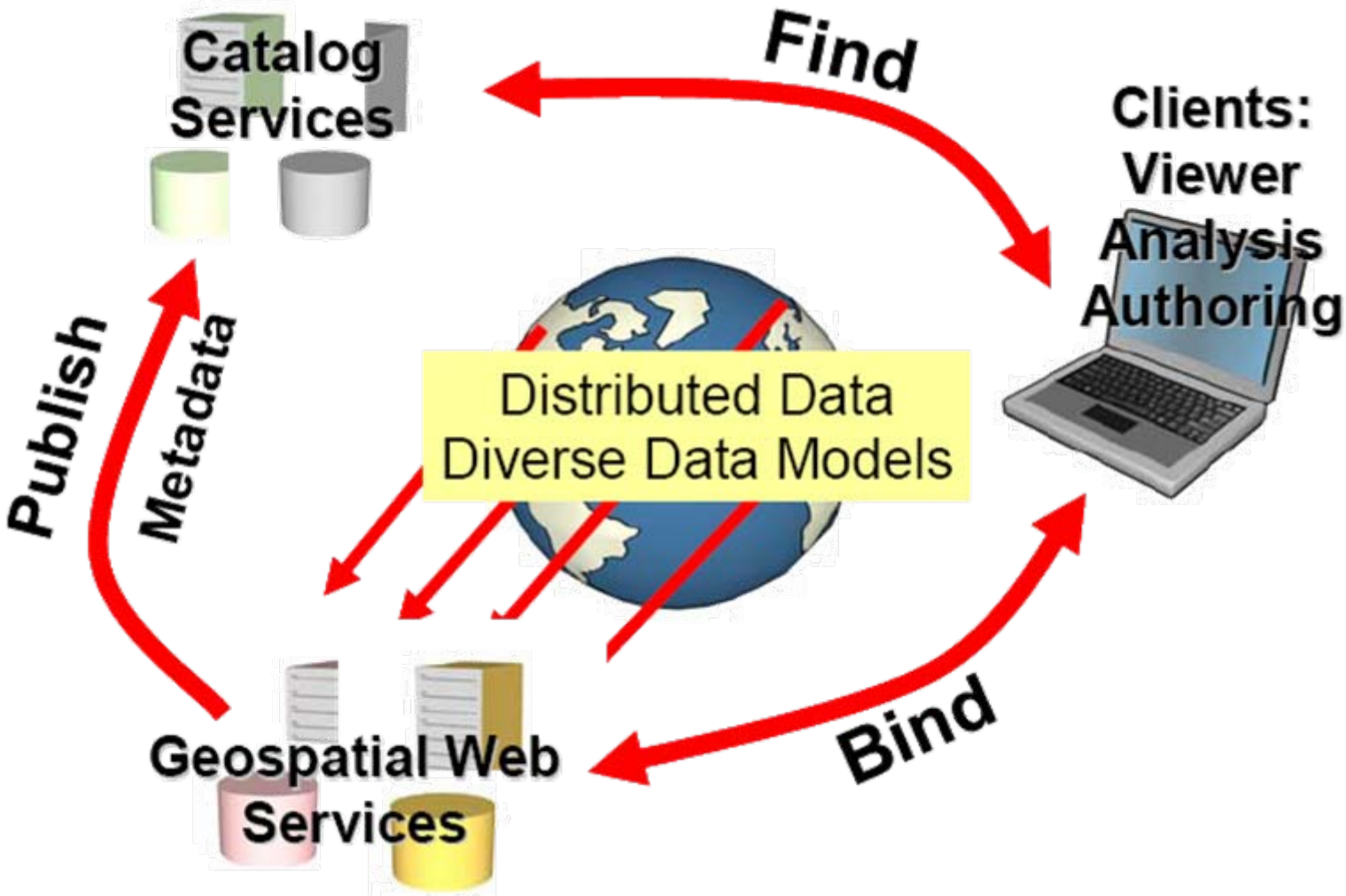
noise pollution maps for European Union reporting (using WMS)

Application Example 4: Homeland Security

Testbed OWS-4 of the Open Geospatial Consortium

- Runtime 6/2006-12/2006
- Fictive Scenario:
  Explosion of a „dirty bomb“ in New York harbour area
- Aim: **Supporting the planning staff** with the installation of a **field hospital**
  - Finding an appropriate location
  - Identification of a suitable building (size, room sizes, air conditioning)
  - Thematic queries & visual inspection
- Coupling of different OGC Web Services and client applications, data formats: **CityGML** and **IFC**

Service-oriented System Architecture (SOA)



Grafik: Paul Cote, Harvard Graduate School of Design

OGC Testbed #4 – System Architecture

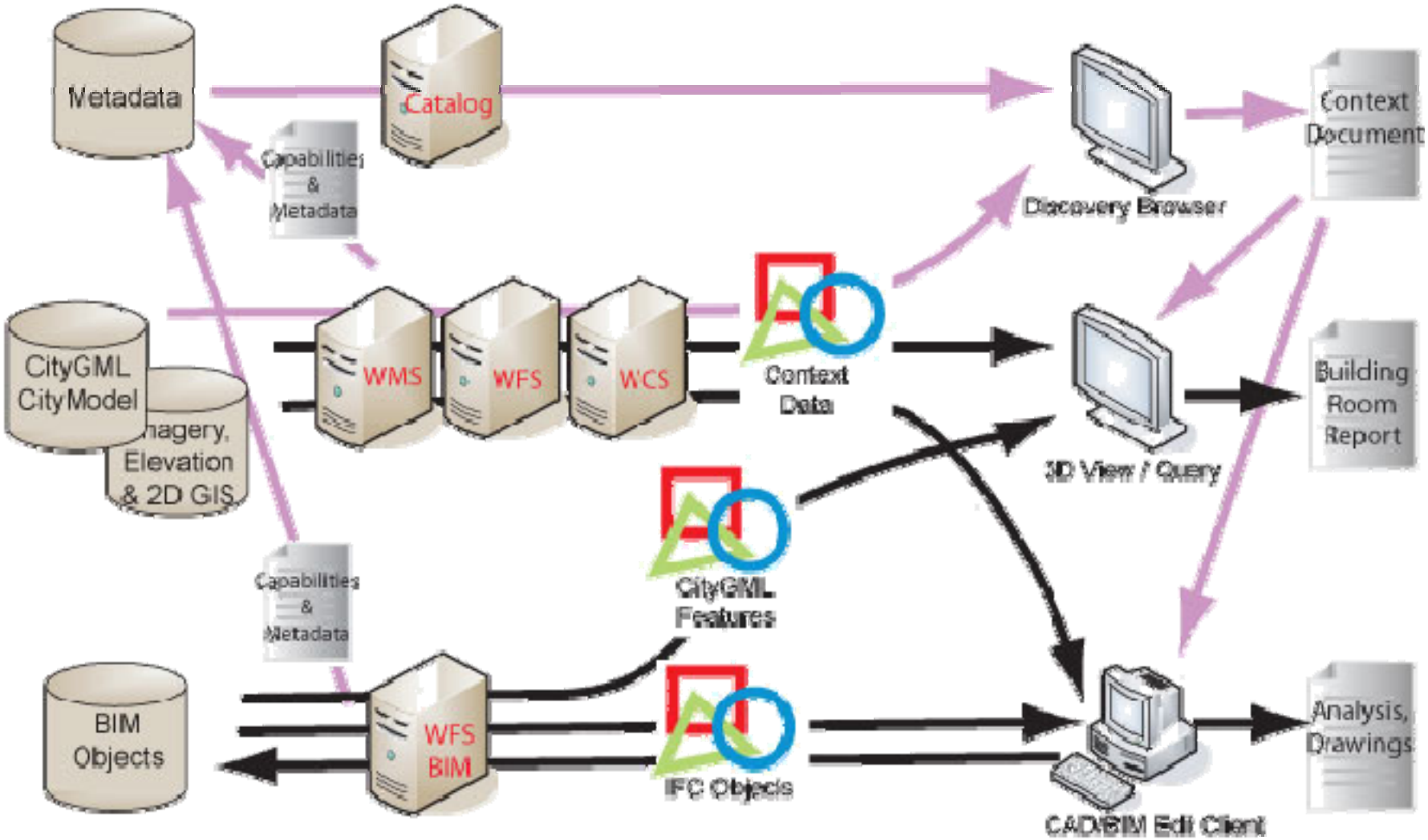


Illustration: Paul Cote, Harvard Graduate School of Design

Application Example 4: Homeland Security