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Implementing 3D Geovisualization in Spatial Data Infrastructures: The Pros and Cons of 3D Portrayal Services

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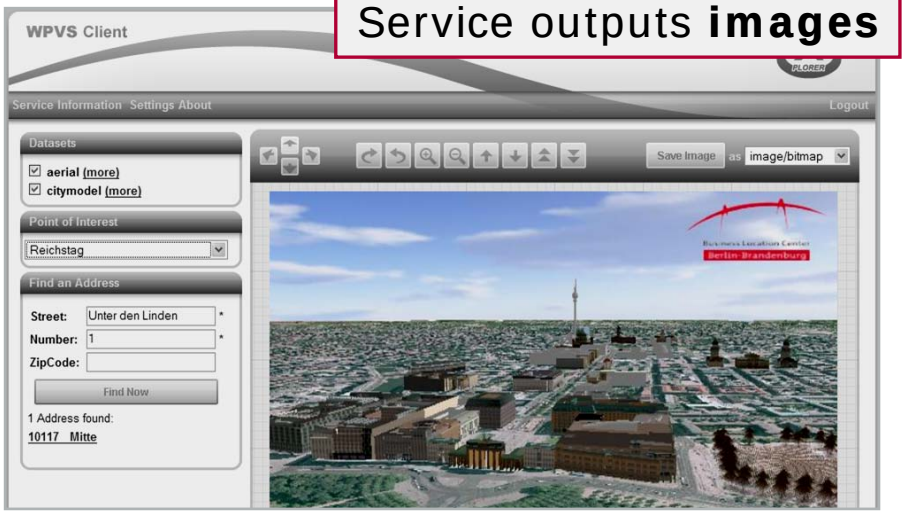
Motivation

- Visualizing geodata using distributed resources
  - Visualizing geodata is essential for many applications
  - Leveraging distributed geodata and functionality as services is often advantageous
  - Geodata cannot be visualized “directly”
- Web 3D Portrayal Services
  - Offer functionality for visualizing geodata
  - Service types differ fundamentally in output representation and capabilities

Service outputs **scene graphs**

Service outputs **images**



➔ What are the pros and cons of different types of portrayal services?
➔ Which types of portrayal services are appropriate to meet which requirements?

Agenda

1. Virtual 3D City Models

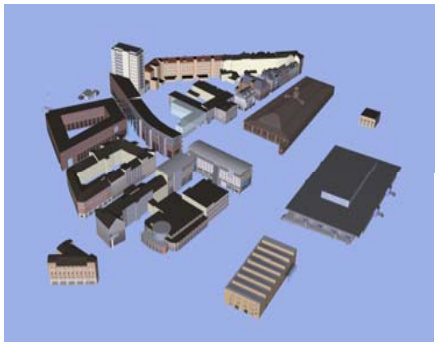
2. Web 3D Portrayal Services
3. Service Capabilities
4. Service Comparison
5. Current Research “WPVS+” and Video Demonstration

6. Conclusions

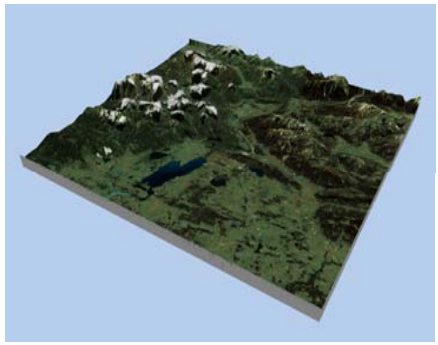
1 Characteristics of Virtual 3D City Models

Virtual 3D City Models

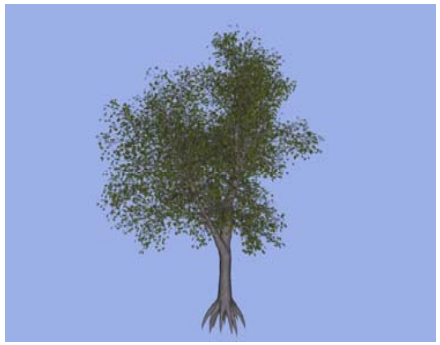
- *"Digital, georeferenced representations of spatial objects, structures, and phenomena of urban areas"* [Döllner2008]
- Essential components of SDIs as integration platforms for georeferenced information
- Inherently complex in multiple dimensions (semantics, geometry, appearance, storage,…)



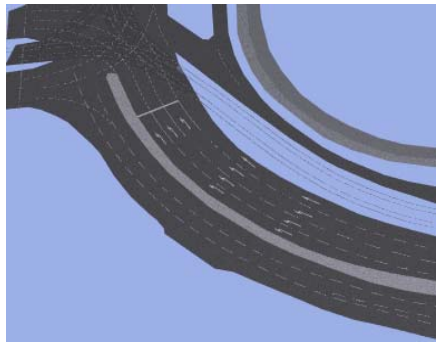
Buildings (LOD-1..4)



Terrain and aerophotos

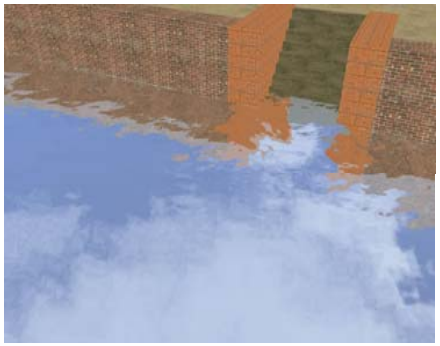


Vegetation

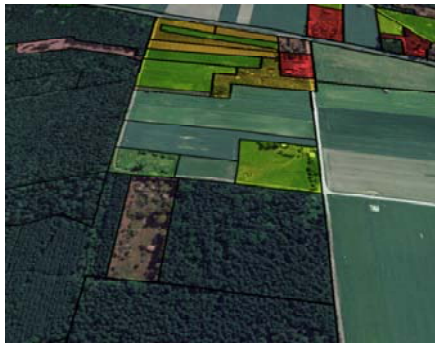


Transportation objects

City furniture



Water bodies



Land use

Grouping

1 Characteristics of Virtual 3D City Models

Storage Requirements for a Hypothetical City Model of Berlin

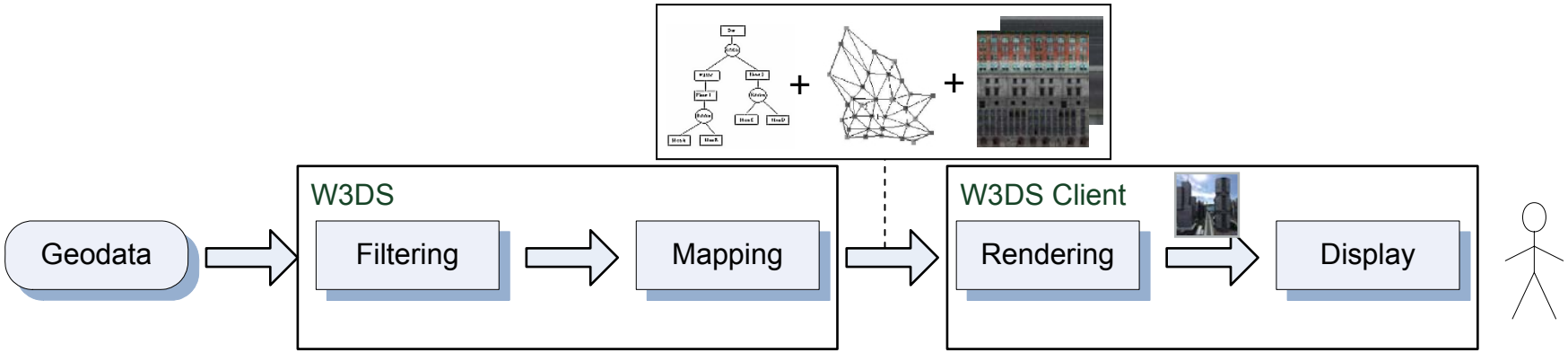
- Approx. 890 km², 550.000 buildings

Component	Type	Res.	Format	Storage
Terrain	Geometry	5m	Raw	294 MB
	Texture	0,2m	S3TC	10.610 MB
Buildings	Geometry	LOD1	Compr. CityGML	180 MB
	Texture	512^2 Pixel	S3TC	71.500 MB
			Total	**82.584 MB**

➔ City models put high demands on portrayal services

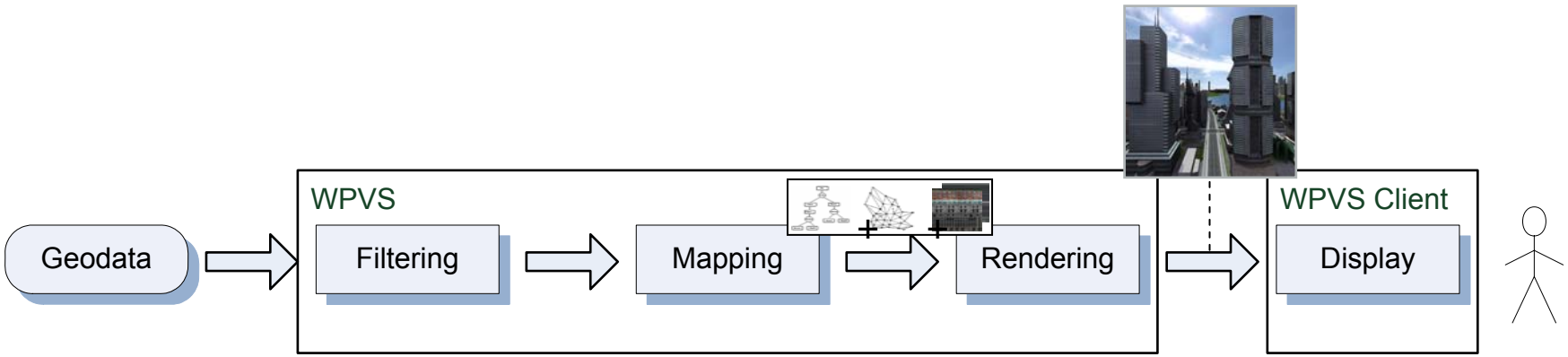
Web 3D Service (W3DS, OGC Proposal)

- Output
  - **Scene graphs** plus geometry and textures that need to be rendered by the client
  - Complex data structures, distributed and interlinked data
- Rendering
  - Implemented by client
  - Restricted by employed scene graph description (e.g., VRLM, X3D)
- User manipulation of content and camera specification
  - Low latency manipulation of scene graph elements and camera



Web Perspective View Service (WPVS, OGC Proposal)

- Output
  - **Images** ready to be displayed by client
  - Simple data structure
- Rendering
  - Implemented and fully controlled by service
  - Can implement complex, sophisticated techniques and optimizations
- User manipulation of content and camera specification
  - High latency since again a call to the service is required



3.1 Service Capabilities

Capabilities

- Orthogonal to basic portrayal service type (W3DS and WPVS)
- Significant impact on applicability, performance, scalability and implementation complexity of portrayal service

- Capability “Integrated”
  - Portrayal service stores geodata **locally** and can portray the contained geodata
  - Portrayal service advertises sets of predefined layers and predefined styles

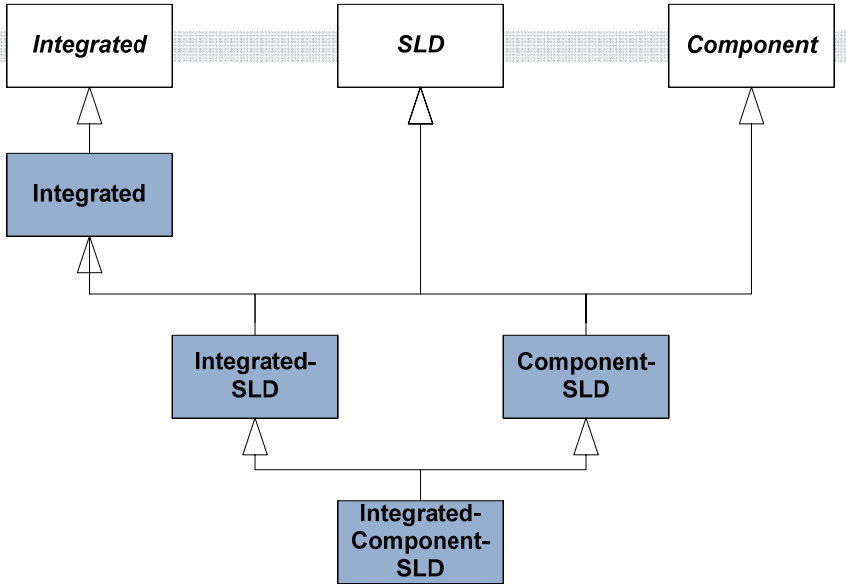
- Capability “Component”
  - Portrayal service supports accessing and portraying **remote** geodata

- Capability “Styled Layer Descriptor (SLD)”
  - Portrayal service supports selective and user-defined portrayal
  - SLD documents (XML) offer fine-grained control over **what** geodata is to be portrayed and **how** it is to be styled

3.2 Service Capabilities

Capability Types

- Three basic capabilities can be combined to model four different capability types



- Individual strengths and weaknesses
  - When to use which capability type from a client perspective?

	High performance portrayal	Control of how to style what geodata	Appropriate for small geodata from any source	Ability to integrate geodata on vis. level
Integrated	✓	-	-	-
Integrated-SLD	(✓)	✓	-	-
Component-SLD	-	✓	✓	✓
Integrated Component-SLD	(✓)	✓	✓	✓

4.1 Service Comparison

Criterion / Portrayal Service Capability Type	W3DS				WPVS				WPVS+
	I	I-SLD	C-SLD	IC-SLD	I	I-SLD	C-SLD	IC-SLD	I-SLD
Visual quality	o	–	–	–	+	o	o	o	+
Client–side characteristics									
Possible degree of interaction	o	++	+	+	– –	o	–	–	+
Process integration complexity	– –	o	o	o	o	++	++	++	o
Software development effort	–	– –	– –	– –	++	+	+	+	o
Software installation required	–	–	–	–	+	+	+	+	o
Required hardware resources	–	–	–	–	+	+	+	+	o
Administration and maintainance effort	–	–	–	–	+	+	+	+	o
Network communication									
Transmission load service to client	– –	– –	– –	– –	++	++	++	++	+
Transmission load to service	++	++	– –	– –	++	++	– –	– –	++
Server–side characteristics									
Software development effort	o	–	–	–	–	– –	– –	– –	– –
Required hardware resources	–	– –	o	– –	–	– –	–	– –	– –
Administration and maintainance effort	–	–	o	–	– –	– –	–	– –	– –
Geodata and content aspects									
Geodata integration	–	–	++	++	– –	– –	+	+	o
Geodata udpating	–	– –	++	o	–	– –	++	o	– –
Licensing and privacy	o	o	–	–	++	++	+	+	+

4.2 Service Comparison

Most Suitable Service Type for Isolated Requirements

- What are the strengths of the respective portrayal service types?
- Which service type to choose when focusing on an isolated requirement?

Visual Quality and Client-Side Characteristics

Requirement	**Most Suitable Portrayal Service Type**
High quality visual representations	WPVS-Integrated
High degree of interaction	W3DS-Integrated-SLD
Easy process integration	WPVS-*-SLD
Low software development & installation effort	WPVS-*
Low required hardware resources	WPVS-*
Low administration and maintenance effort	WPVS-*

4.3 Service Comparison

Network Communication and Server-Side Characteristics

Requirement	Most Suitable Portrayal Service Type
Low transmission load from service to client	WPVS-*
Low transmission load to service	W3DS-Integrated, WPVS-Integrated
Low software development effort	W3DS-Integrated
Low required hardware resources	W3DS-Component-SLD
Low administration and maintenance effort	W3DS-Component-SLD

Geodata and Content Aspects

Requirement	Most Suitable Portrayal Service Type
Geodata integration	W3DS-Component*-SLD
Geodata updating	W3DS-Component-SLD, WPVS-Component-SLD
Licensing and privacy	WPVS-Integrated

4.4 Service Comparison

Conclusions of the Comparison

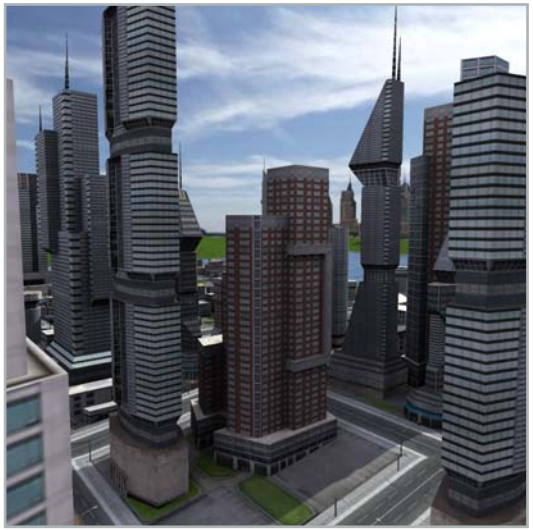
- A multitude of 3D portrayal service types exists
- Portrayal service types differ significantly in individual strengths and weaknesses
- Simplified tendencies: WPVS better on client-side/network criteria,
  W3DS better on server-side criteria, no tendencies on geodata and content criteria
- No portrayal service type can meet all relevant requirements, e.g.,
  no portrayal service type offers at the same time
  - High quality visual representations
  - High degree of interactivity
  - High degree of control over what and how to portray
  - High performance portrayal
- Consequences
  - For practice: Choose service type according to thoroughly captured and prioritized requirements
  - For research: Many challenges (e.g., interaction, performance) still need to be addressed

5.1 Current Research “WPVS+”

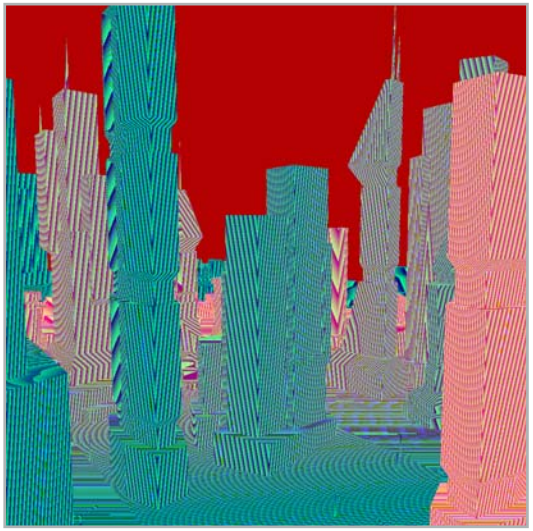
WPVS+ Service

- Goal
  - Strike a balance between W3DS and WPVS capabilities
  - Improve the visualization and interaction capabilities of WPVS clients
- Functional extension of WPVS
  - Providing additional thematic information layers for generated WPVS images
  - Encoded in images per pixel: color, spatial depth, object identification, and more

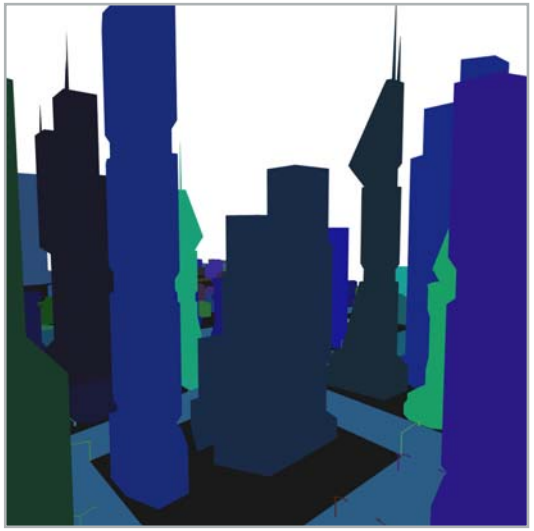
Color layer



Depth layer



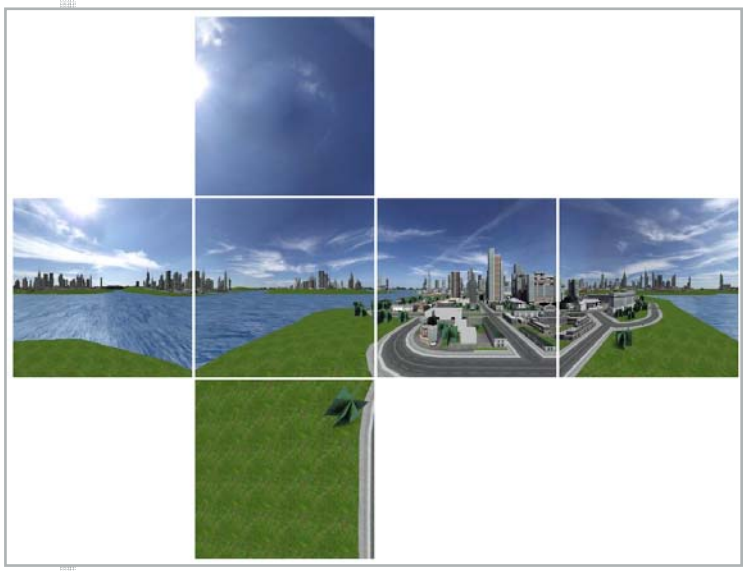
Object ID layer

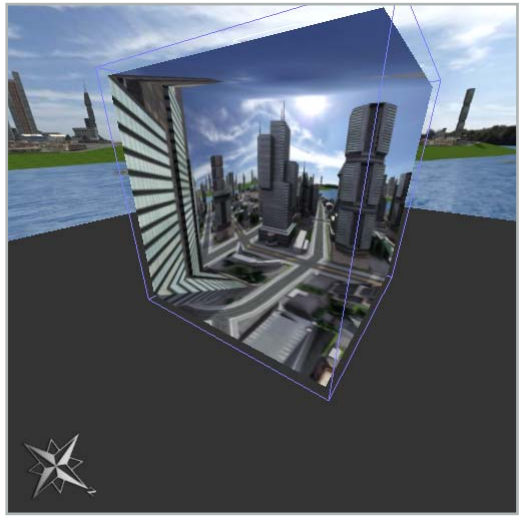


5.2 Current Research “WPVS+”

WPVS+ Client: Experimental, Web-Based, Real-Time 3D Viewer

- Main Purpose
  - Exploration of massive, virtual 3D city models through the Internet based on server-side 3D rendering together with lightweight clients
- Concept
  - Service generates cube maps of 3D environments
  - Cube maps are transferred to images sequences to client
  - Image-based reconstruction of the 3D environment by the client
  - Interaction within the virtual cube with progressive transfer of new cube maps





5.3 Current Research “WPVS+”

WPVS+ Client: Experimental, Web-Based, Real-Time 3D Viewer

- Potentials
  - “Massive 3D virtual worlds for small devices” without having to stream original geodata
  - High quality, advanced visualization (powerful server-side rendering)
  - High degree of interactivity giving the illusion of desktop-like 3D rendering
  - Efficient use of the Internet for information transfer

- Implementation
  - Work-in-progress prototype,
    currently under development at HPI

Video Demo

6 Conclusions

Conclusions

- Distribution offers potentials but adds complexity

- Multitude of 3D portrayal service types
- Portrayal service types differ significantly in strengths and weaknesses
- No portrayal service type meets all relevant requirements
- When choosing a portrayal service, requirements should be assessed carefully

- Many challenges (e.g., interaction, performance) still need to be addressed
- Current research “WPVS+” tries to strike a balance between W3DS and WPVS

Thank you for your attention!