

# Smart Buildings – A Concept for Ad-Hoc Creation and Refinement of 3D Building Models

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Structure of the Talk

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- 1 Smart Buildings – An Overview
- 2 Limitations of Discrete Levels of Quality
- 3 Characteristics of Smart Buildings
- 4 Conclusions & Future Work

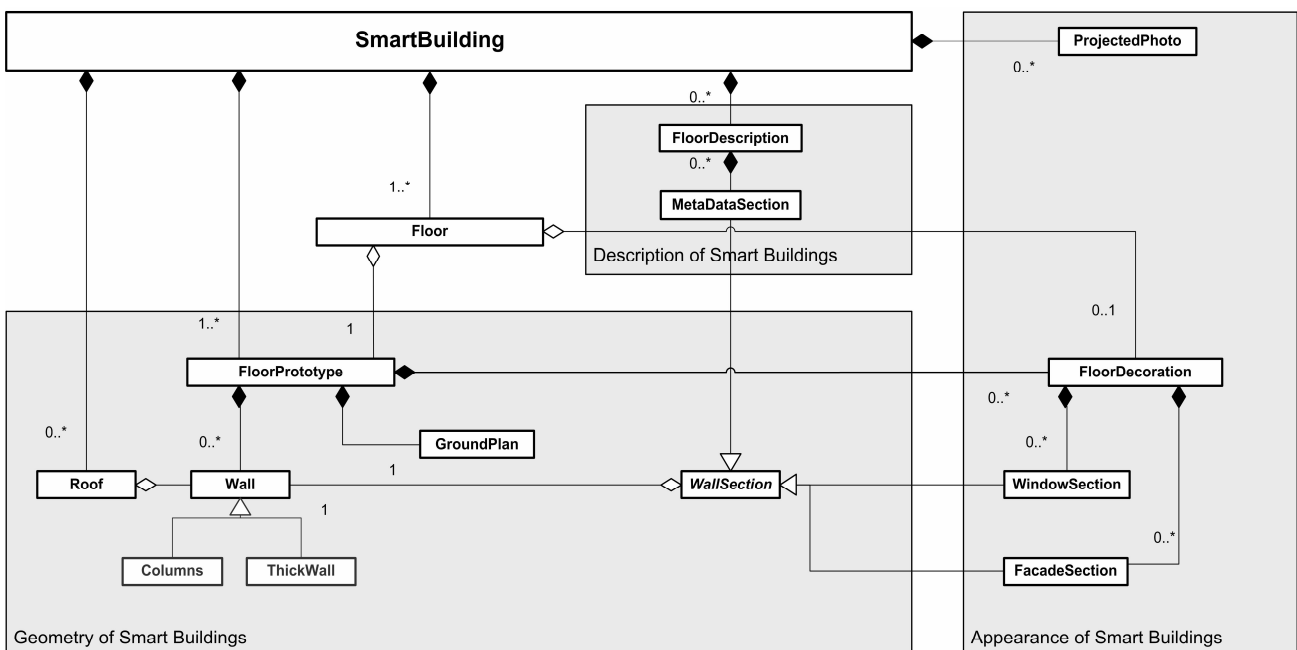
# Smart Buildings

A concept for representing building models at a continuous level of quality



# Smart Buildings

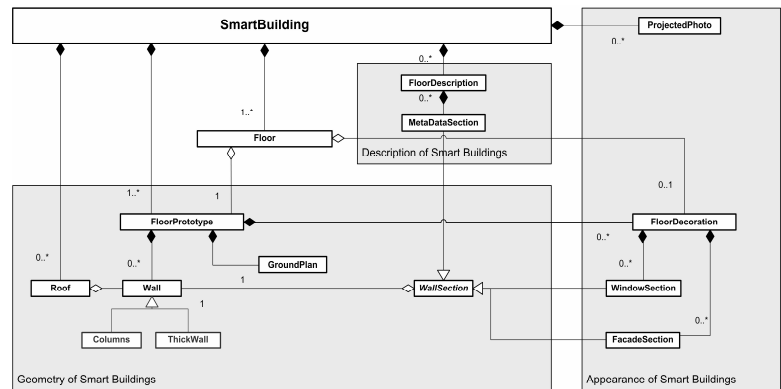
A concept for representing building models at a continuous level of quality



# Smart Buildings

A concept for representing building models at a continuous level of quality

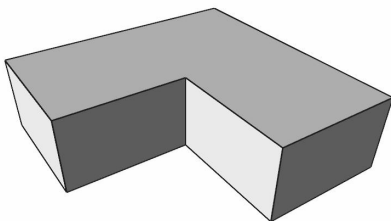
- facilitating incremental refinement operations
- allows for expressing a variety of building characteristics
- integrates application-defined semantics as first-class objects
- can express LOD-1 to LOD-4 buildings and building at in-between quality levels (e.g., "LOD-1.7", "LOD-3.5")



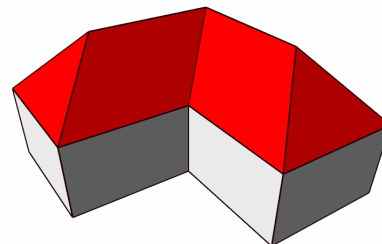
## 2 Limitations of Discrete Levels of Quality

### Levels of Quality for Building Models

- Four principal *quality levels*: LOD-1, ..., LOD-4



Block Model (LOD-1)



Block Model with Roof (LOD-2)



Detailed 3D Model (LOD-3)



Indoor 3D Model (LOD-4)

For details, see papers, e.g., A. Altmeier & Th. Kolbe, 2003.

## Characteristics

- LOD-1 & LOD-2 Buildings
  - automated generation, even for large numbers of buildings
  - abstractions of buildings, visual simplicity
- LOD-3 & LOD-4 Buildings
  - manual design, supported by semi-automated techniques
  - specified based on detailed 3D geometry and textures
  - expensive in terms of time and costs

## Observations

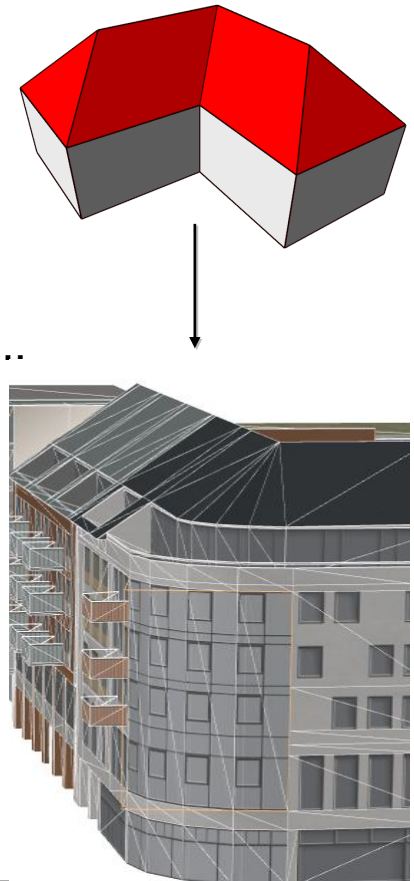
- *sharp separation between four discrete levels (in terms of geometry, appearance, modeling schema, ...)*
- *applications frequently find models that are too simple (...appearance) or too expensive (...costs)*

## The long-term management of 3D city models

- *demands for transforming existing models into more complex ones (frequently event-driven)*
- *demands for tools to create sketches of buildings in an ad-hoc manner*
- *would benefit from a more integrated conceptual and technical representation*

### Examples of 3D City Model Operations:

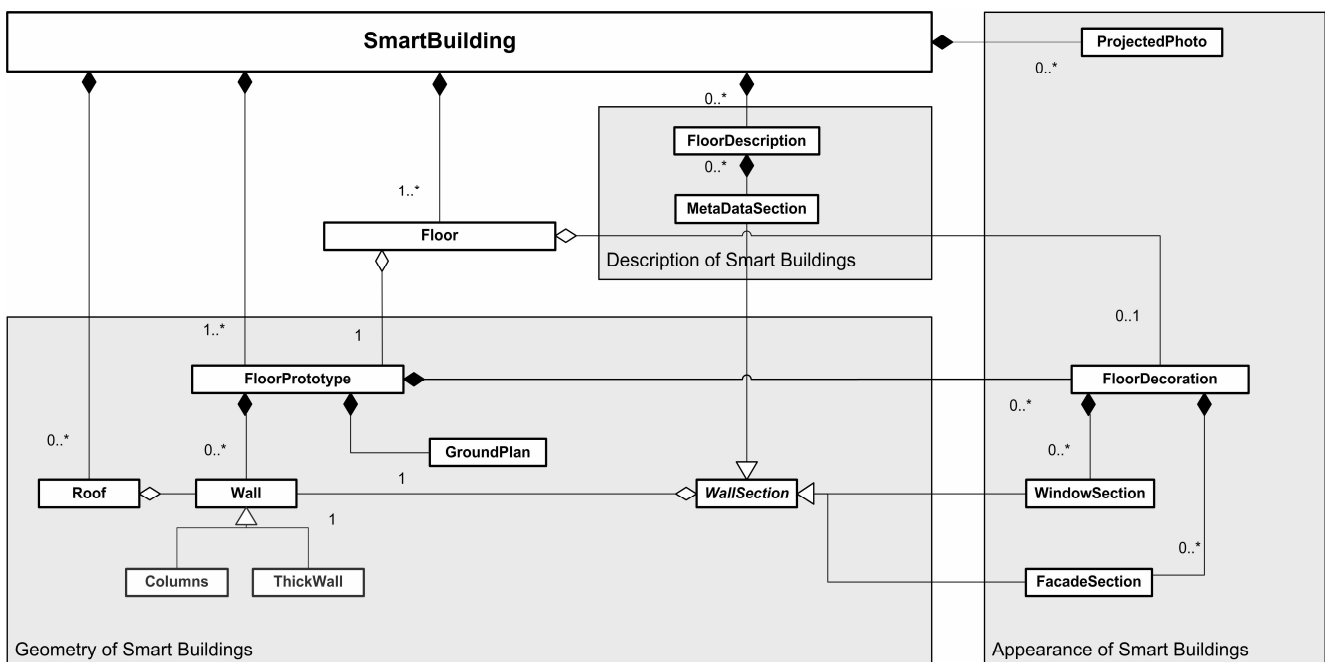
- Adding perceptual significant details to buildings
- Adding different skinnings to facades
- Adding/removing/changing floors, roofs, ...
- Adding thematic information (application-defined data) to buildings and building parts
- ...



These operations represent typical operations required by *interactive 3D city model authoring tools.*

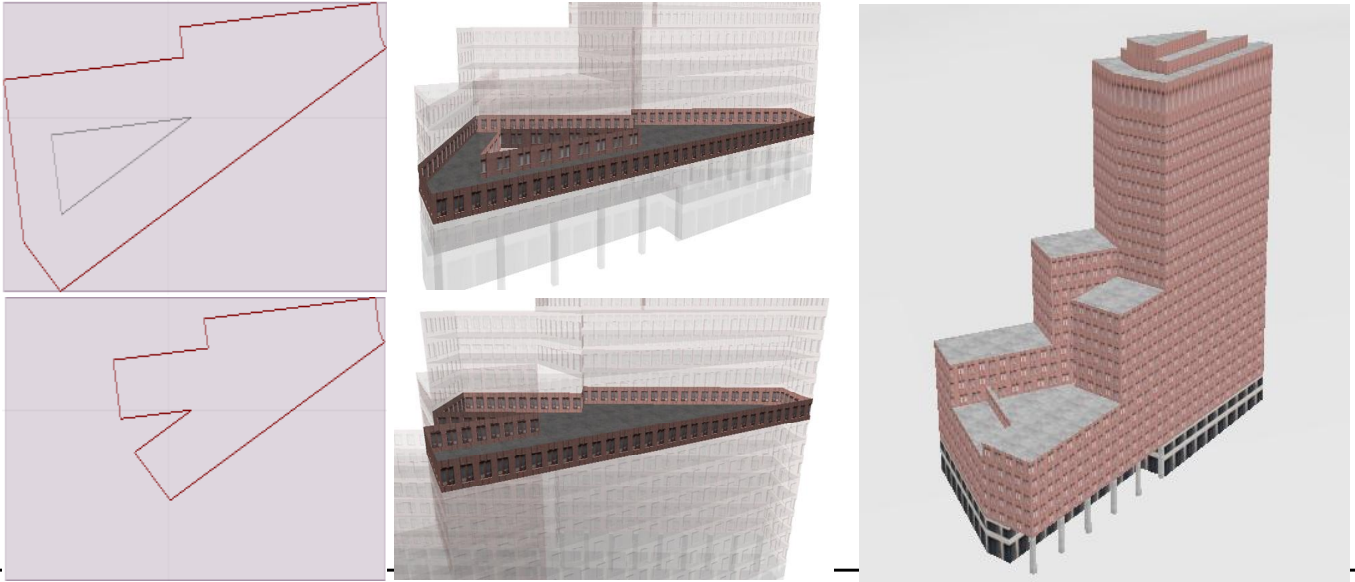
### 3 Characteristics of Smart Buildings

### Smart Buildings – The Underlying Object Model



## Geometry of Smart Buildings

- Specification is based on *floor objects*
- Each floor object is an instance of a *floor prototype* (most buildings like to replicate floor plans)
- Floor prototypes are defined by *walls*



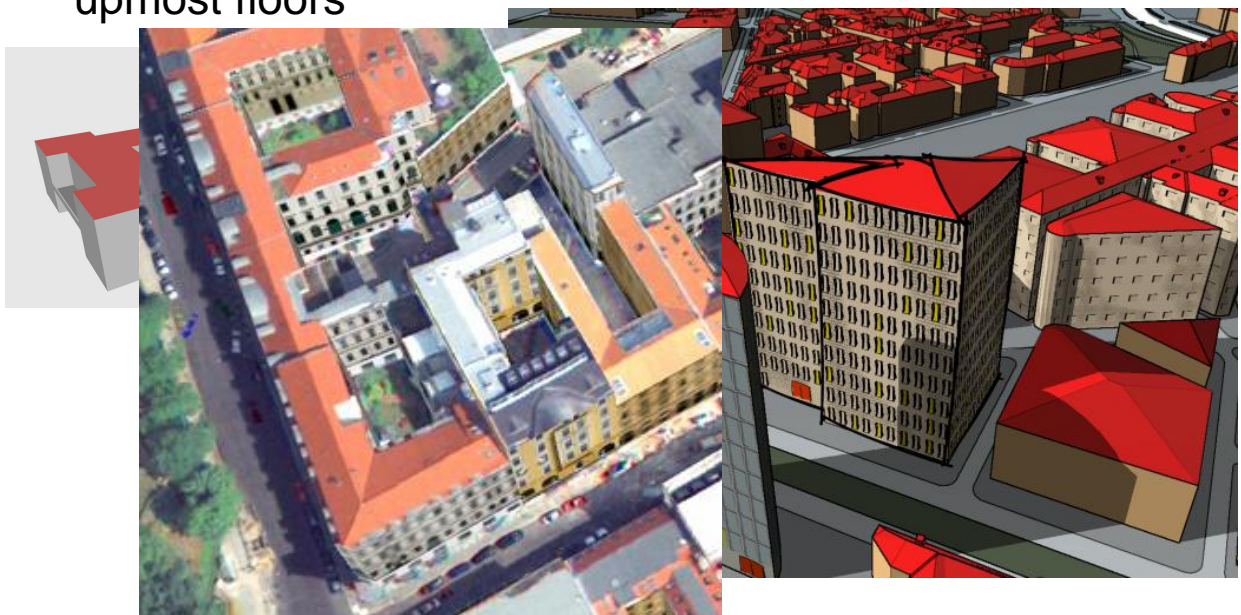
Next Generation 3D City Models

Jürgen Döllner HPI Potsdam

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## Geometry of Smart Buildings

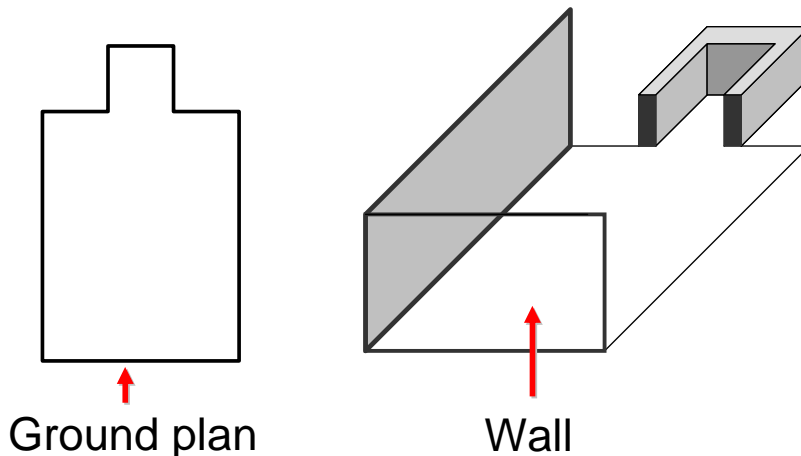
- *Roofs* represent specialized geometry, attached to the upmost floors



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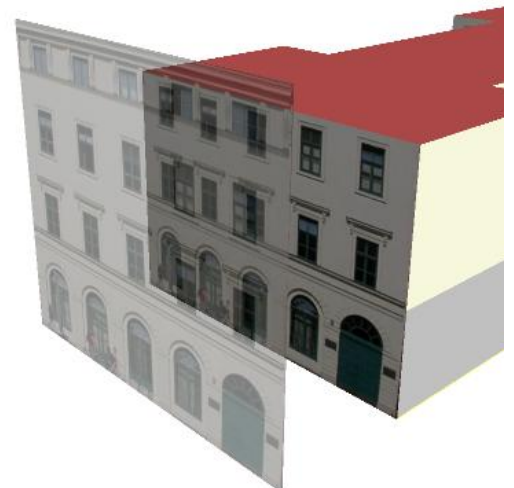
## Geometry of Smart Buildings

- *Ground Plan*: one or more (generalized) polygons
- Walls are specified by one or more (generalized) polylines
- Wall height and wall thickness can be specified as well



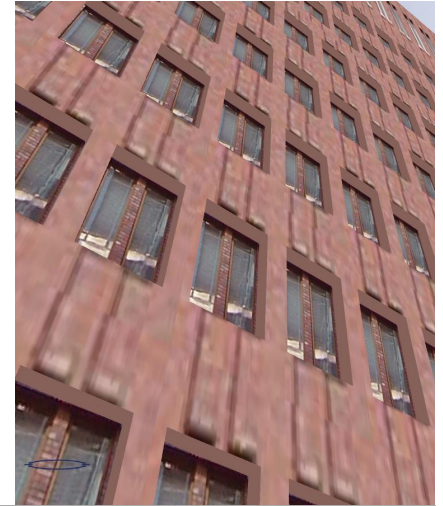
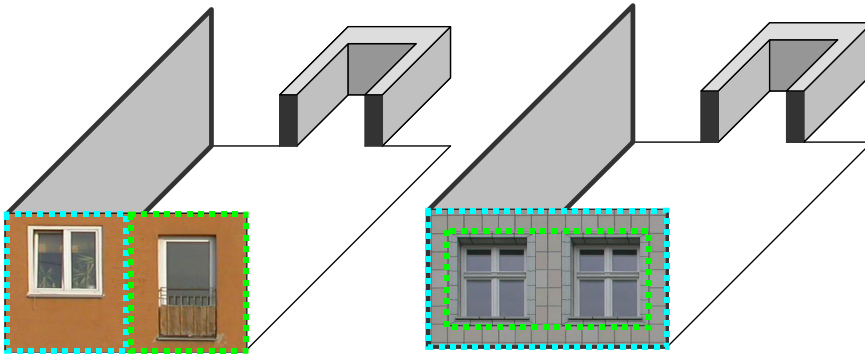
## Appearance of Smart Buildings: *Projective Textures*

- Place an imaginary projection wall in front of a facade, represented by *ProjectedPhoto* objects
- Defines an orthogonal projection of a texture using projective texturing
- All facades within the projection frustum are affected



## Appearance of Smart Buildings: *Procedural Textures*

- Appearance attributes for floors, walls, or sections of walls
- Appearance specified by texture image patterns or material properties (... "facadlets")
- Specialized specification of windows can be considered in the geometry

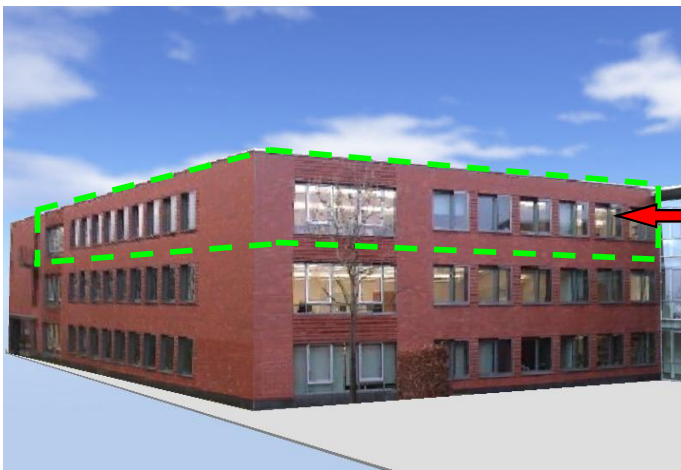


## Projective Textures vs. Procedural Textures

- Projected Facade Textures
  - Simplify the integration of captured photo data
  - Can be restricted to specific buildings parts regardless of their position within the projection frustum
- Explicit Facade Textures
  - Suitable for non-existing buildings and regular facade textures
  - Can enhance facades textured by projected photos *locally*
  - No problems with occluded image parts

## Thematic Data of Smart Buildings

- Application-defined data attached to buildings is essential for all applications operating on 3D city models
- Thematic data can be attached to buildings, floors, walls, or wall sections; sections are most flexible.
- Thematic data stored as an attribute table that define values for a user-specified set of data categories



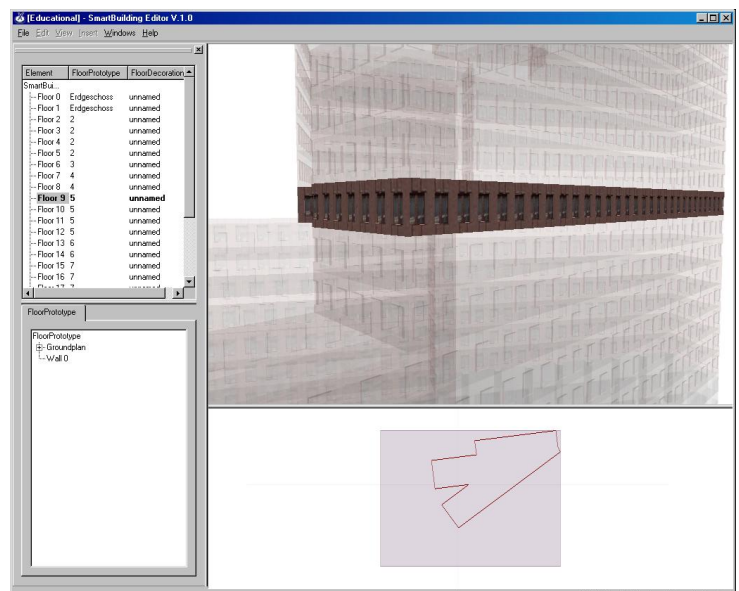
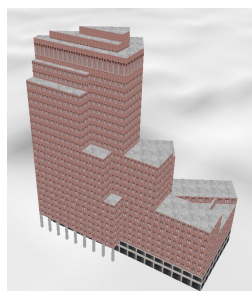
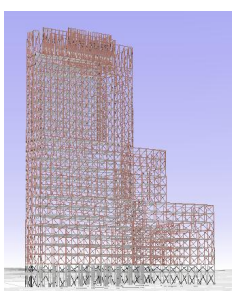
Key	Value
Workgroup	Computer Graphcis Systems

Close

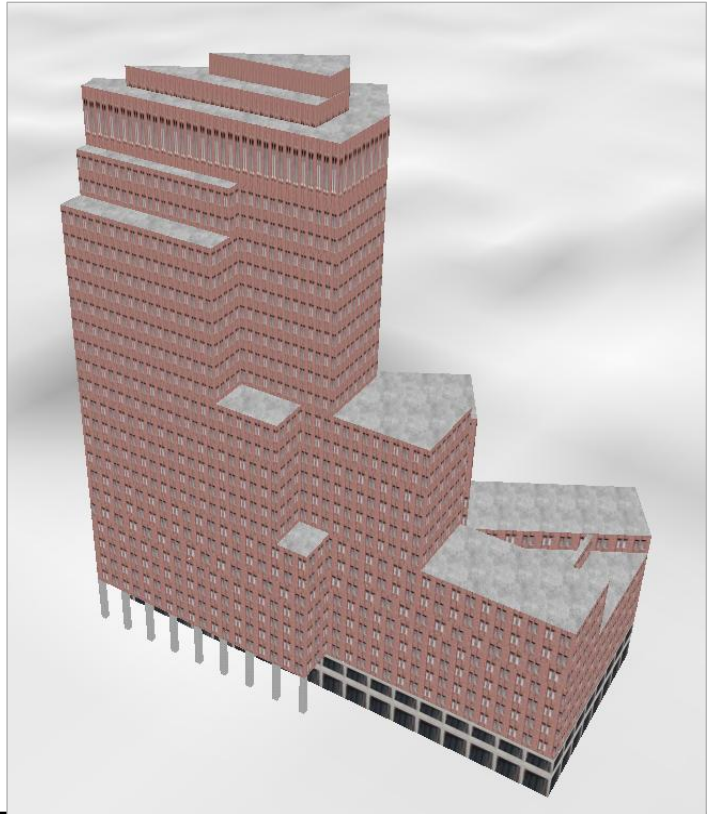
## 3 Characteristics of Smart Buildings

### The Smart Building Editor

- Provides a direct manipulation interface to smart buildings
- Supports translating LOD-1 and LOD-2 models to smart buildings (ongoing work)
- Supports translating CityGML models to smart buildings (ongoing work)
- Implemented as a part of the LandXplorer system ([www.landexplorer.net](http://www.landexplorer.net))



### The Smart Building Editor



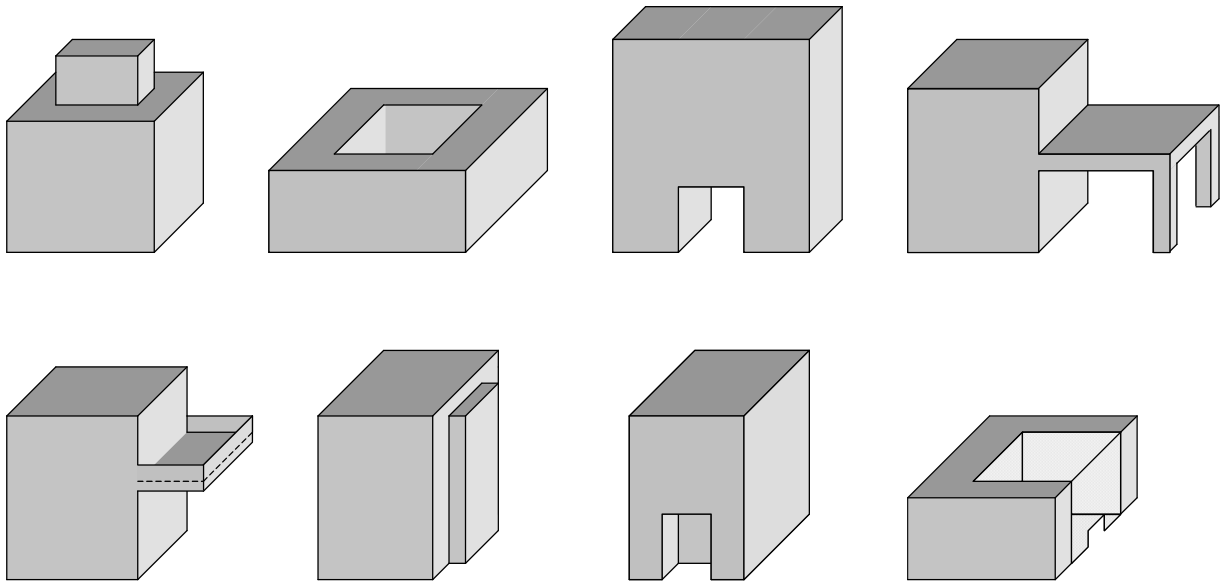
## 4 Conclusions & Future Work

### Conclusions

- Floors, Floor Prototypes, Walls, Wall Sections, Wall Descriptions serve as **flexible, simple, and powerful components**
- Smart Buildings facilitate tools for ad-hoc construction of simple buildings ("**LOD-1.x**" building class)
- Smart Buildings tools provide operations for adding detail to existing models ("**LOD-2.x**" building class)
- Even main characteristics of (perceptual important) indoor structures can be modeled, such as in the case of an atrium ("**LOD-3.x**" building class)
- Smart Buildings are suited for **direct manipulation** in 2D (floor prototypes) and 3D (appearance, descriptions)
- Smart Buildings provide the basis for **semantics-driven rendering optimization**

## Conclusions

- Smart Buildings are able to express a (large) variety of **common building features**



Upcoming Paper: Döllner, Buchholz. Continuous LOD Modeling of 3D Objects

## Work in Progress

- Components and tools for roof skeletons and additional, frequently demanded features such as stairs, dormers, ...
- More automation for facade texturing: *Facadlets*
- Automated transformation between Smart Buildings and CityGML, 3DS, and other 3D formats
- Real-time non-photorealistic rendering styles for Smart Buildings (talk tomorrow...)

[www.hpi.uni-potsdam.de/~doellner](http://www.hpi.uni-potsdam.de/~doellner)  
[www.landexplorer.net](http://www.landexplorer.net)