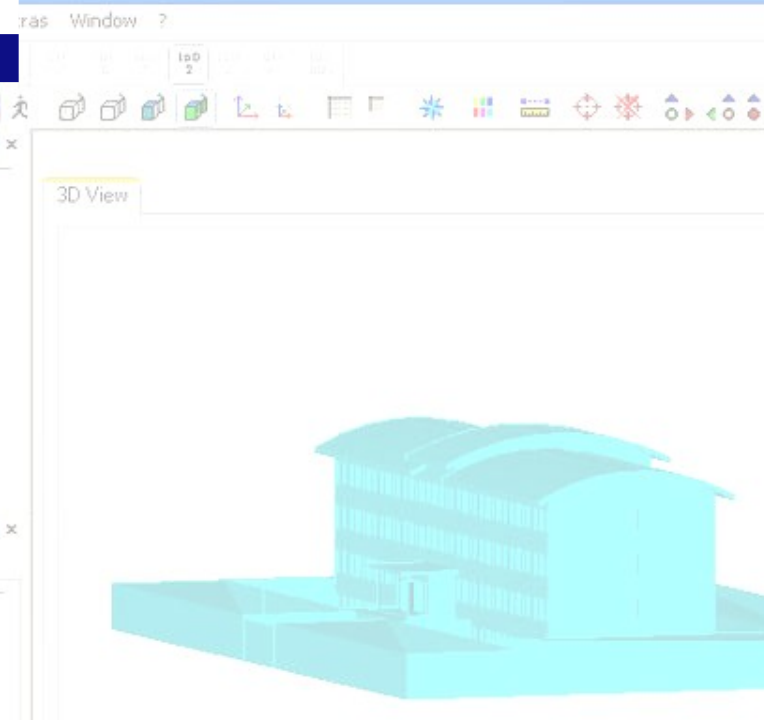
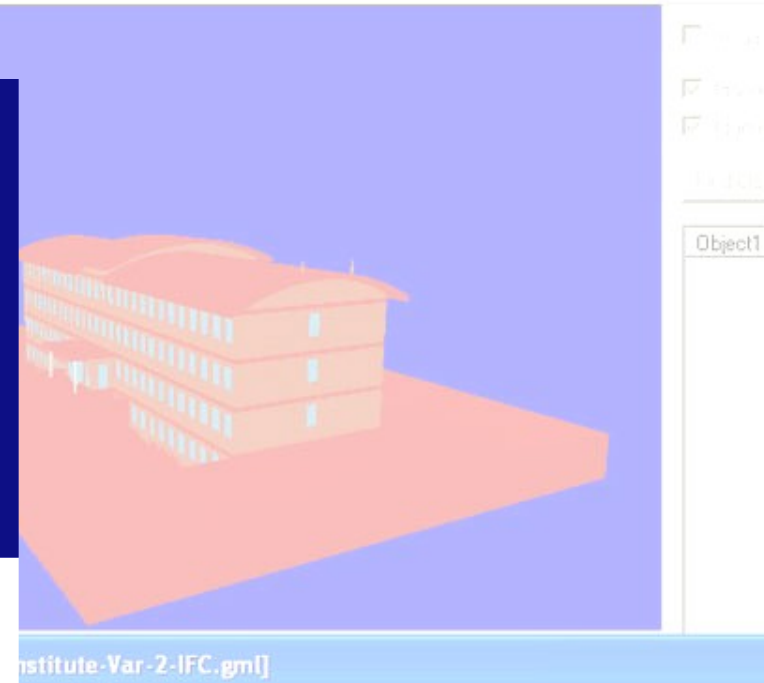


CityGML Extension for BIM / IFC information

Léon van Berlo

TNO | Knowledge for business



The talk:

- Netherlands organisation for applied scientific research TNO
- CityGML
- BIM – IFC
- We come from the BIM/IFC world !
- Integrating GIS and BIM (past work from heroes)
- Extending CityGML with ADE
- The BIM/IFC ADE
- Why we want to do this?!
- Implementation (BIMserver.org; citygml4j)
- Demo / screenshots
- Conclusions
- Limitations
- Future ambitions
- More info

45 slides... :-S

The introductions

TNO (Netherlands organisation for applied scientific research)
Largest Dutch R&D centre,
Non-profit,
Raised by law
Mission: innovate companies and government

Five Core Areas (#5000 people)



**TNO Quality
of Life**



**TNO Defence,
Security and
Safety**

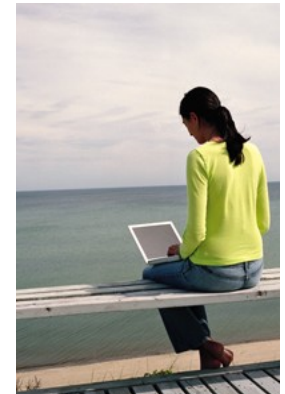


**TNO Science
and
Technology**



**TNO Built
Environment
and
Geosciences**

(the cool one)



**TNO Information
and
Communication
Technology**

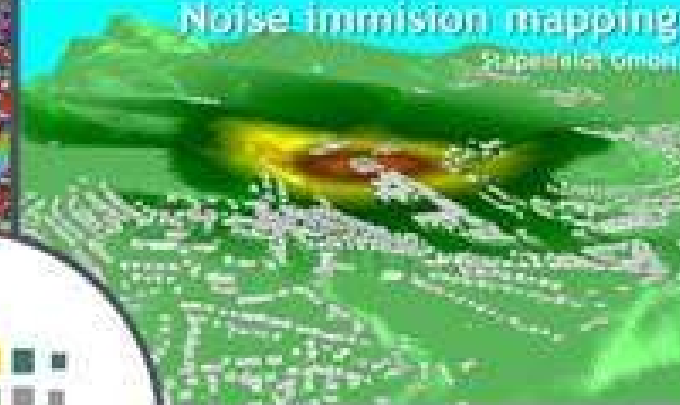
Disaster management
Kreis Riedlinghausen



Radio network planning
Telekom



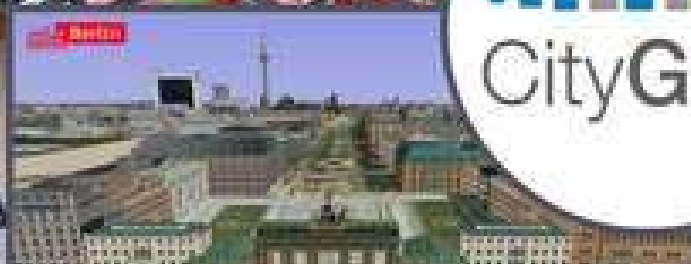
Noise immission mapping
Rupelhof GmbH



for 3d city models



Police simulator
Prüfungsall-berence Electronics

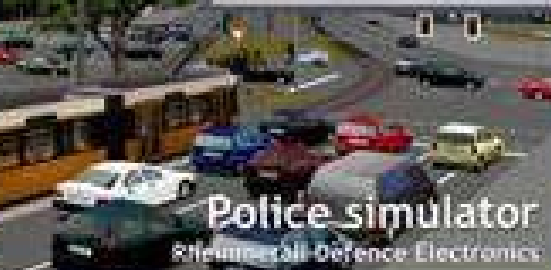


Business development
& tourism
Landscape



Münsterplatz

Navigation



Facility management



Urban planning



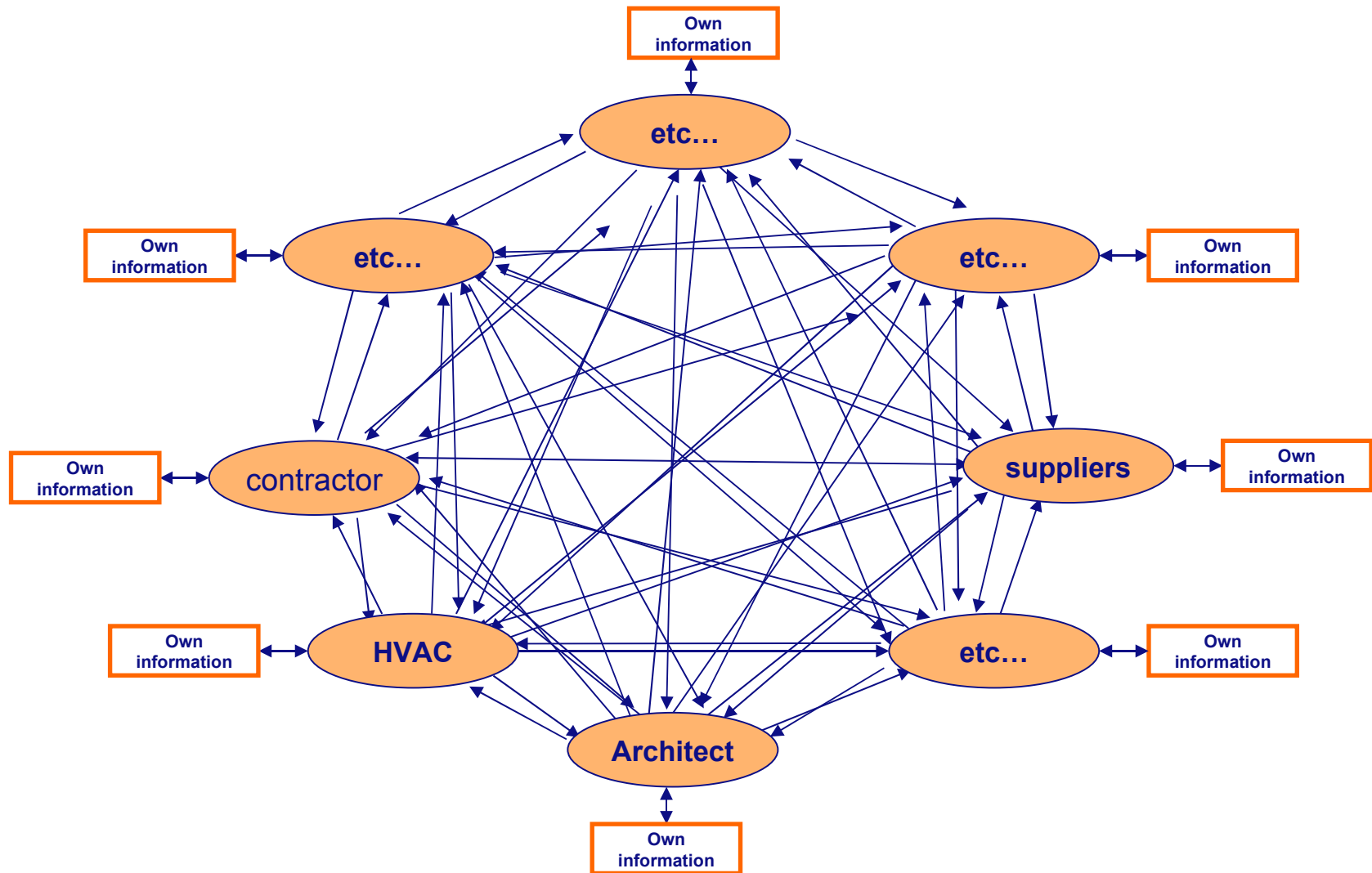
Architecture

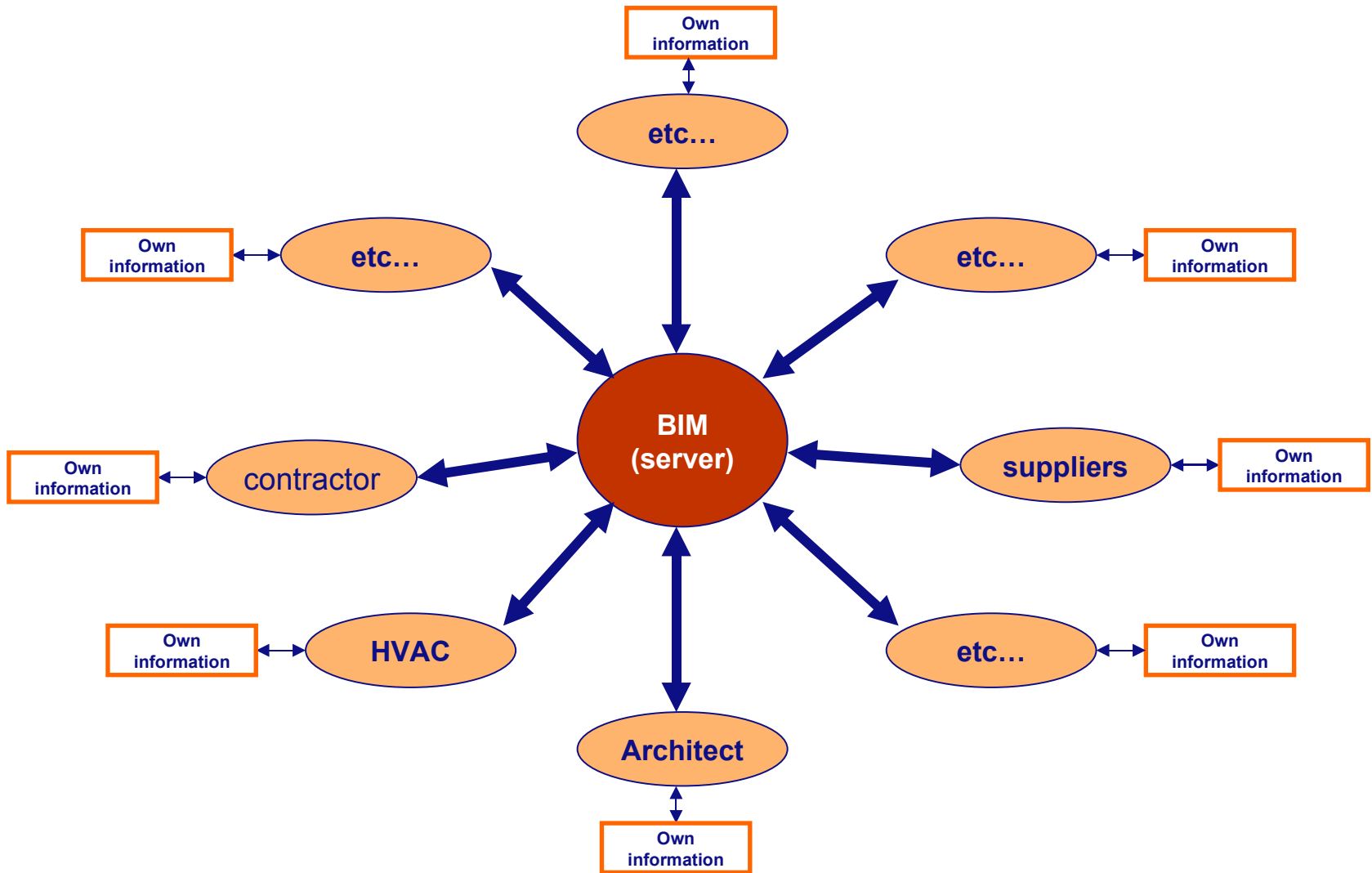
Architekturwerkstatt SenStadt Berlin

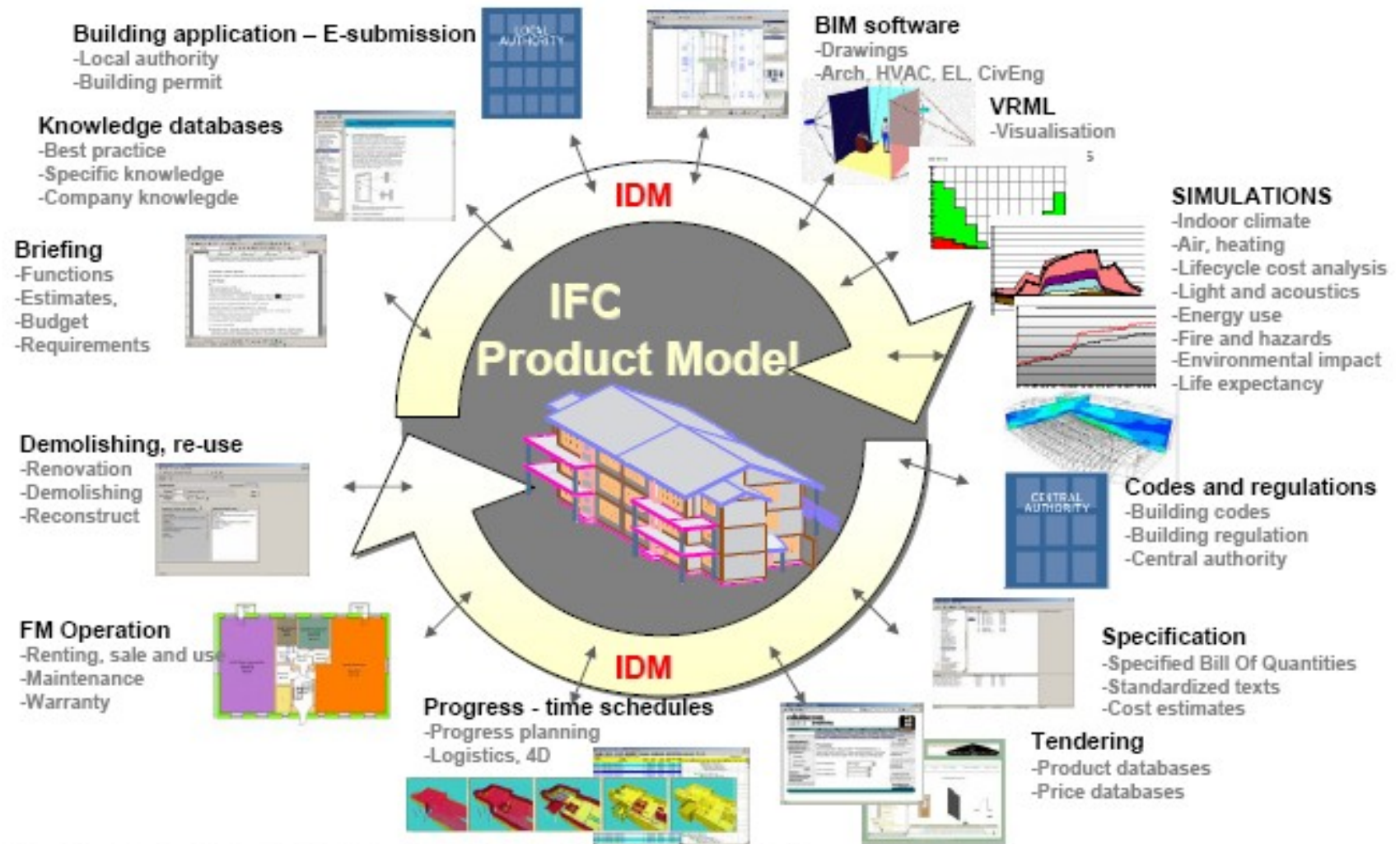
Building Information Modelling (and IFC)

- Integrated information about a building
- All disciplines work with the same information
- IFC as the open standard for data/file exchange

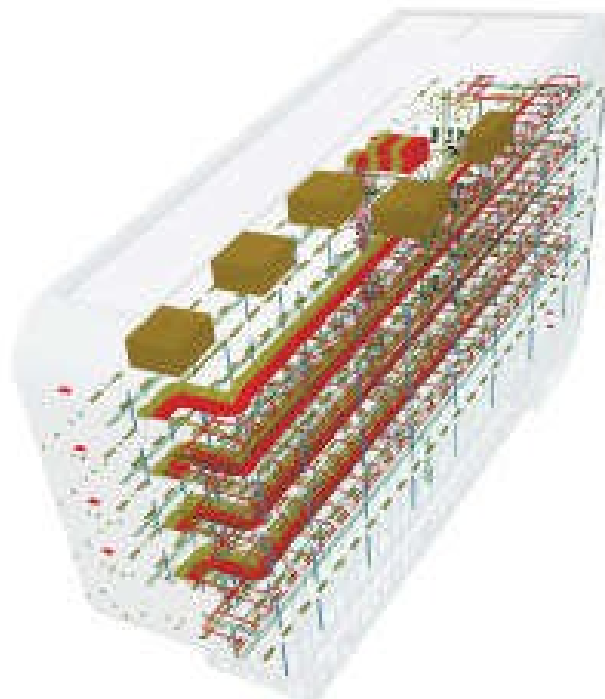
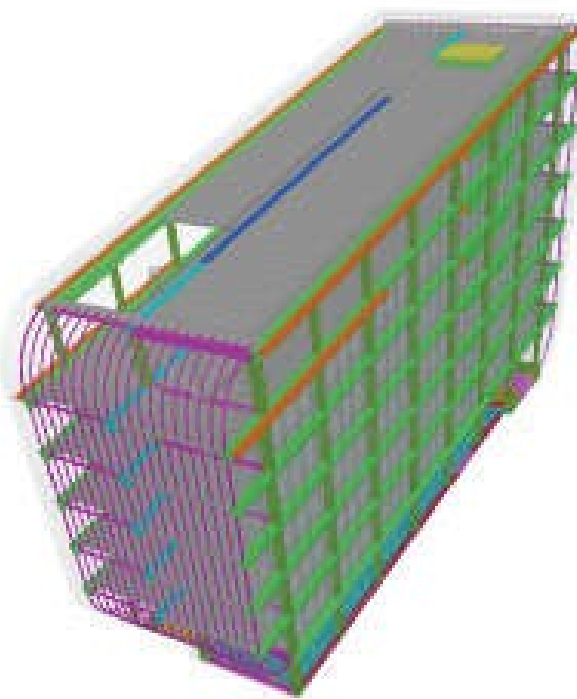
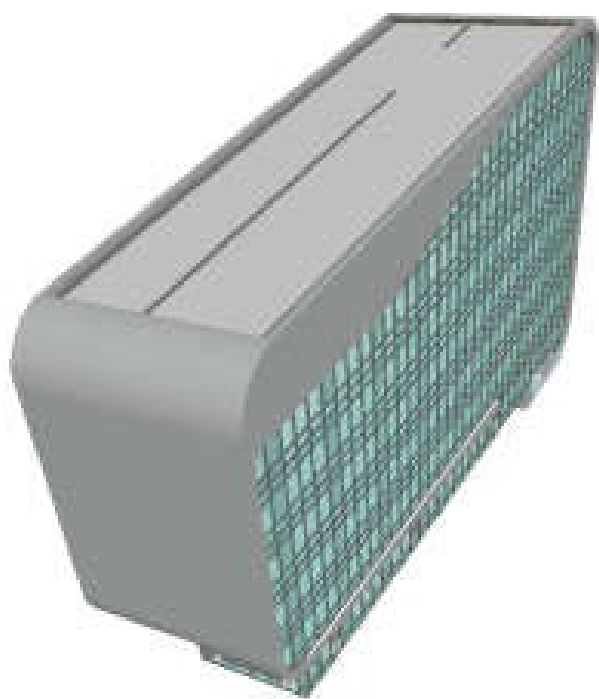
“event driven” information exchange







Pictures from: Selvaagbygg, DDS, Byggforsk, NBLN University of California, CIFE Stanford, Pythagores and Oluf Granlund Yo.



IFC: Industry Foundation Classes

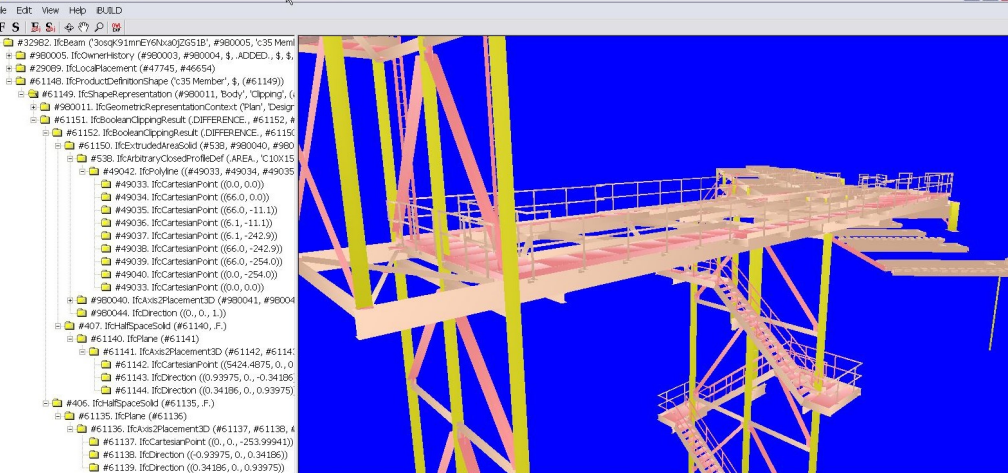
- Industry Foundation Classes
- 'Open' standard
- Is coming from the 'CAD-world'
- From the first days of the STEP time (1985)
- Autodesk as driver back in the 1980's
- *Meant* to be a standard for 'downstream applications'
- *Used* as an exchange standard
- Latest version: 2x3 TC1



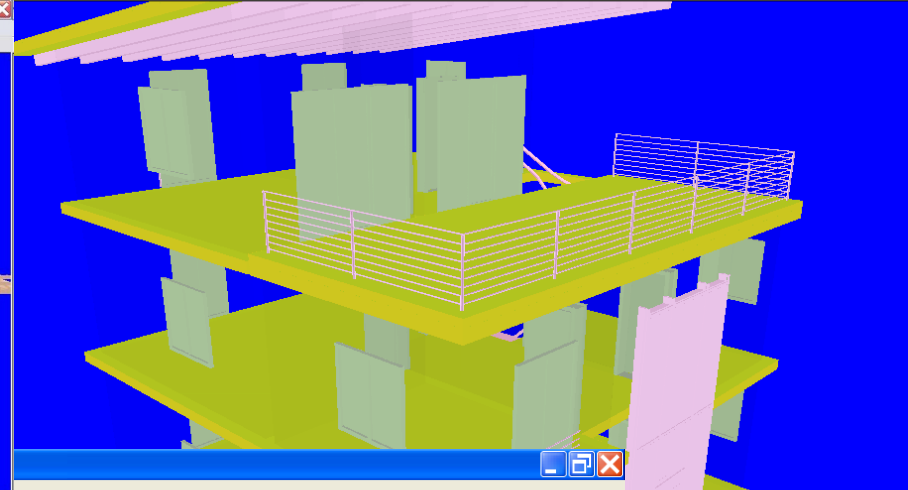
```

|ISO-10303-21;
HEADER;
FILE_DESCRIPTION (('Bimserver.org 0.8RC1 generated IFC file'), '2;1');
FILE_NAME ('First Project.1', '2009-09-10T08:22:33', ('Administrator'), (''), 'Bimserver.org 0.8RC1', '', 'Administrato
FILE_SCHEMA (('IFC2X3'));
ENDSEC;
DATA;
#6= IFCORGANIZATION('GS','Graphisoft','Graphisoft',$,$);
#11= IFCCARTESIANPOINT((0.,0.,0.));
#19= IFCDIRECTION((1.,0.,0.));
#23= IFCAPPLICATION(#6,'11.0','ArchiCAD 11.0','ArchiCAD');
#60= IFCPOSTALADDRESS(.HOME.,'Home Address','private','Germany',$,'3640','Karlsruhe','Baden-Wuerttemberg','76021','Gern
#63= IFCPERSON('007','Haefele','Karl-Heinz',$,$,$,$,($60,#67,#75));
#67= IFCPOSTALADDRESS(.OFFICE.,'Office Telecom Address','official','Building 445',$,$,'Eggenstein-Leopoldshafen ','B.-U
#75= IFCPOSTALADDRESS(.OFFICE.,'Office Postal Address','official','Germany',$,'3640','Karlsruhe','Baden-Wuerttemberg','
#84= IFCPERSONANDORGANIZATION(#63,#85,$);
#85= IFCORGANIZATION('', 'Karl-Heinz Haefele','Forschungszentrum Karlsruhe',($89),($92));
#89= IFCACTORROLE(.ARCHITECT.,'', 'Hobby Architect');
#92= IFCPOSTALADDRESS(.OFFICE.,'', '', 'Germany',$,$,'Karlsruhe',$,$,$);
#105= IFCOWNERHISTORY(#84,#23,$,.NOCHANGE.,$,$,$,1215091190);
#108= IFCSPACE('3cjmMny5DF0g1J6kKZW04Y',#105,'015',$,$,$,121440,#30860,'Flur Keller West',.ELEMENT.,.INTERNAL.,$);
#113= IFCSPACE('3Gz7u_d1P7IA35Wmtg48Rc',#105,'016',$,$,$,121450,#30908,'Flur Keller Treppe',.ELEMENT.,.INTERNAL.,$);
#118= IFCSPACE('1pG7ErnqL79fYOSoJhY$mD',#105,'008',$,$,$,121430,#30734,'WC Herren',.ELEMENT.,.INTERNAL.,$);
#123= IFCSPACE('1nsRm1QQb1xwWpzzFR7Ax3',#105,'009',$,$,$,121460,#30929,'WC Damen',.ELEMENT.,.INTERNAL.,$);
#126= IFCRELAGGREGATES('113wGMIVrEwueKD$h$hYE_',#105,'BuildingStoreyContainer','BuildingStoreyContainer for Spaces',#13
#130= IFCBUILDINGSTOREY('25SMdCQszBi9a18gnrh8LV',#105,'Keller','Basement',$,$,33627,$,$,.ELEMENT.,-3.);
#173= IFCGEOMETRICREPRESENTATIONCONTEXT('Plan','Design',3,1.00000000E-5,#1430,#33591);
#176= IFCSHAPE REPRESENTATION(#173,'Body','SweptSolid',($179));
#179= IFCEXTRUDEDAREASOLID(#192,#206,#207,2.7);
#192= IFCARBITRARYCLOSEDPROFILEDEF(.AREA.,$,$,193);
#193= IFCPOLYLINE(($194,#197,#200,#203));
#194= IFCCARTESIANPOINT((0.3,-0.3));
#197= IFCCARTESIANPOINT((18.3,-0.3));
#200= IFCCARTESIANPOINT((18.,0.));
#203= IFCCARTESIANPOINT((-2.4492127E-16,0.));
#206= IFCAXIS2PLACEMENT3D(#11,#207,#19);
#207= IFCDIRECTION((0.,0.,1.));
#212= IFCPRODUCTDEFINITIONSHAPE($,$,($213,#176));
#213= IFCSHAPE REPRESENTATION(#214,'Axis','Curve2D',($30515));
#214= IFCGEOMETRICREPRESENTATIONCONTEXT('Plan','Model',3,1.00000000E-5,#1430,#30510);
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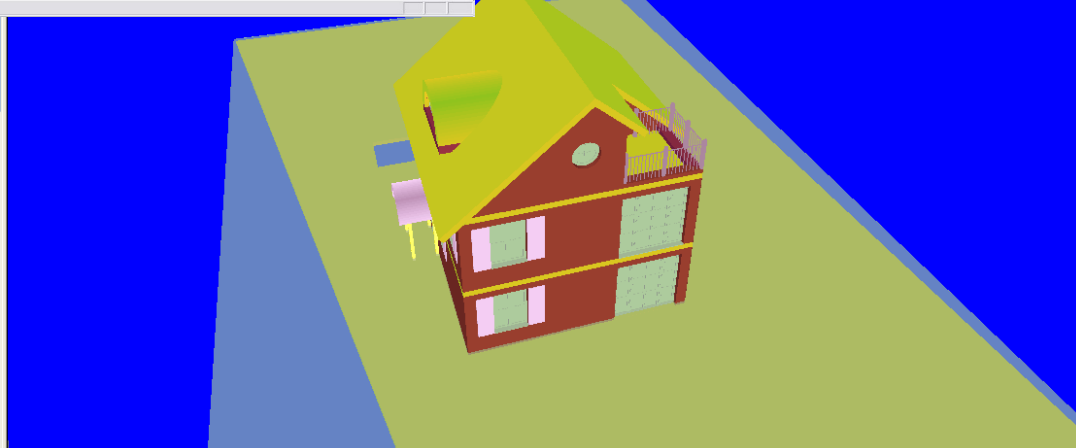
```



Name	Type	Data	Schema Name	Schema Type
Argument... IfcGeometricRepr...	#990011		IfcRepresentation	IfcRepresentation...
Argument... String Type	'body'		Representation...	Optional IfcLabel
Argument... String Type	'Clipping'		Representation...	Optional IfcLabel
Argument... Arguments Type			Items	Set [1..7] of IfcR...
Argument... IfcBooleanClipp...	#61151		IfcBooleanClipp...	
Backlink 0	IfcProductDefini...	#61148		



#1715 = Body (Sweep(Solid), Area = undefined, Volume = 2.308E9)
\$ Name
\$ Description
Representations
#12429. IfcShapeRepresentation (#11, 'Body', 'Brep', (#12428))
ShapeOfProduct
#12431. IfcSlab ('2FCguWau50Fg5Pro7B0Ac', #16, \$, ", \$, #11990, GlobalId '2FCguWau50Fg5Pro7B0Ac')
OwnerHistory
\$ Name
Description "
HasAssignments
IsDecomposedBy
Decomposes
HasAssociations
\$ ObjectType
IsDefinedBy
ObjectPlacement
Representation
#12430. IfcProductDefinitionShape (\$, \$, (#12429))
\$ Name
\$ Description
Representations
#12429. IfcShapeRepresentation (#11, 'Body', 'Brep', (#12428))
ShapeOfProduct
#12431. IfcSlab ('2FCguWau50Fg5Pro7B0Ac', #16, \$, ", \$, #11990, #12430, \$, .ROOF.)
GlobalId '2FCguWau50Fg5Pro7B0Ac'
OwnerHistory
\$ Name
Description "
HasAssignments
IsDecomposedBy
Decomposes
HasAssociations
\$ ObjectType



Name	Type	Data	Schema Name	Schema Type
Argument 0	IfcGeometricRepresent...	#11	IfcRepresentation	IfcRepresentation...
Argument 1	String Type	'Body'	ContextOfItems	Optional IfcLabel
Argument 2	String Type	'Brep'	RepresentationIdentifier	Optional IfcLabel
Argument 3	Arguments Type		RepresentationType	Optional IfcLabel
Argument 3.0	IfcFacetedBrep	#12428	Items	Set [1..?] of IfcR...
Inverse 0			RepresentationMap	Set [0..1] of IfcR...
Inverse 1			LayerAssignments	Set [0..?] of IfcPr...
Inverse 2			OfProductRepresentation	Set [0..1] of IfcPr...
Inverse 2.0	IfcProductDefinitionSha...	#12430	IfcShapeModel	
			OfShapeAspect	
Inverse 3			IfcShapeRepresentation	Set [0..1] of IfcS...

We come from the BIM/IFC world !

- We made the **IFC Engine Series**
 - Free IFC viewer
 - Fastest IFC renderer in the world
 - DLL for IFC implementation
 - www.ifcbrowser.com
- We made the **open source Building Information Modelserver**
 - Free and open source
 - Only *native* BIMserver in the world
 - Based on IFC
 - www.bimserver.org
- We are in all the modelling groups of IFC

The stuff that you're here for.

GIS and BIM – (City)GML and IFC

BIM-world:

- Intense 3D geometry (CSG, Brep, boolean, etc)
- Focus on file exchange
- Focussing above surface objects
- Typically for modelling *new* buildings

Geo-world:

- Focus on server based (central)
- Focussing on areas (x,y)
- Typically for modelling *existing* data

Where two worlds meet...

Learning (stealing) from each other:

- CityGML (3D object-Geo)
- BIMserver.org (server based BIM)
-

Heroes at IFC – CityGML translation

- Thomas H. Kolbe
- Claus Nagel
- Alexandra Stadler
- Gerhard Gröger
- Lutz Plümer

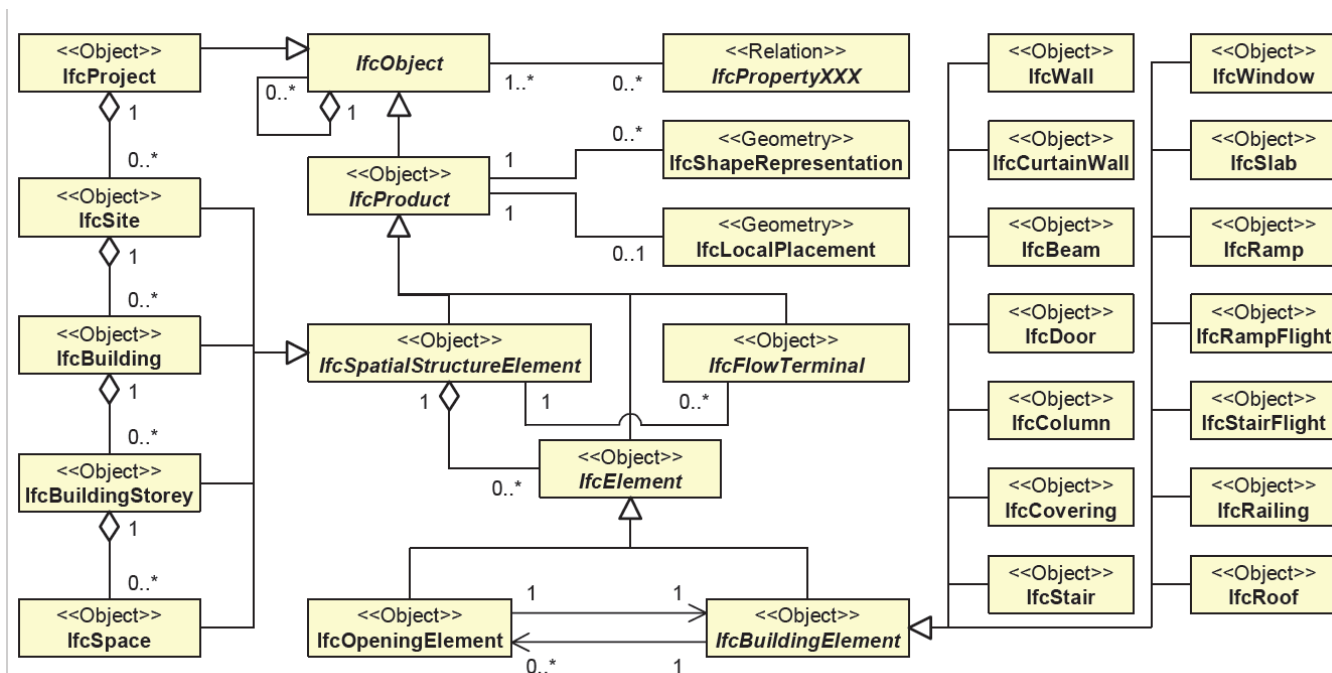
All from the Institute for Geodesy and Geoinformation Science; Berlin
University of Technology

- Karl-Heinz Häfele
- Joachim Benner
- Andreas Geiger
- Klaus Leinemann

Forschungszentrum Karlsruhe; Karlsruhe Institute of Technology

- Thomas Liebich
- International Alliance for Interoperability - AEC3

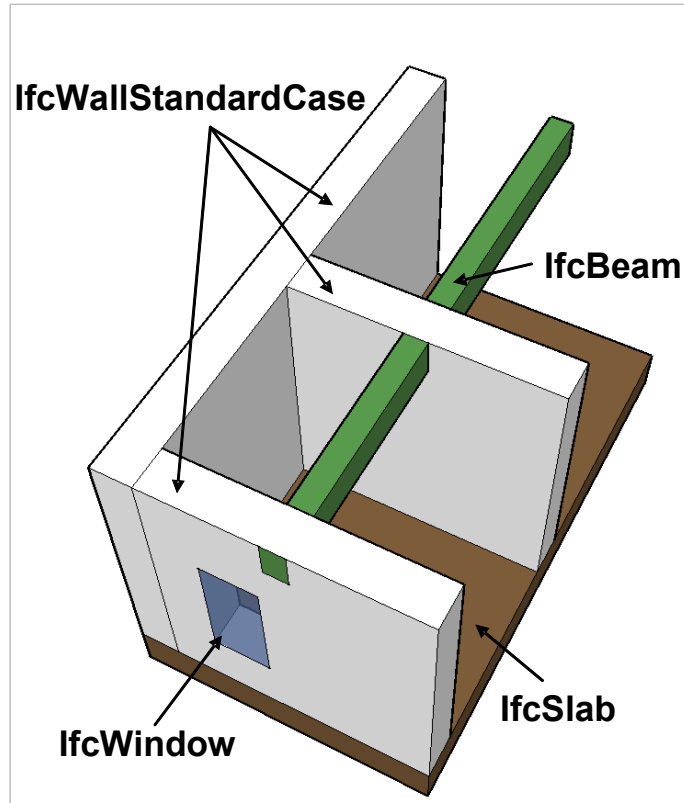
- Sisi Zlatanova
 - Umit Isikdag
- OTB - Delft University of Technology



Differing Modeling Paradigms

BIM (e.g., IFC)

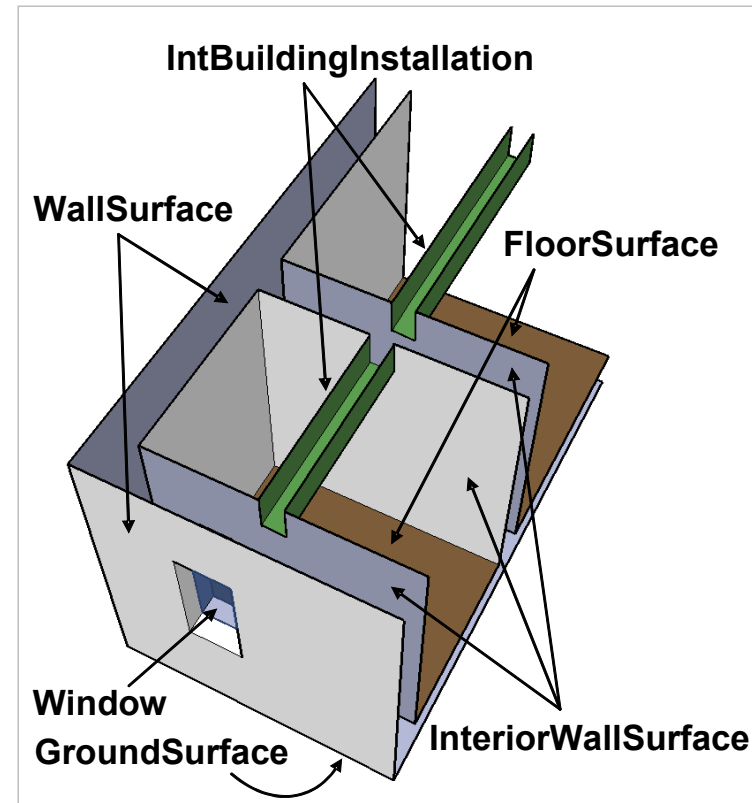
Constructive Solid Geometry



Volumetric, parametric primitives representing the structural components of buildings

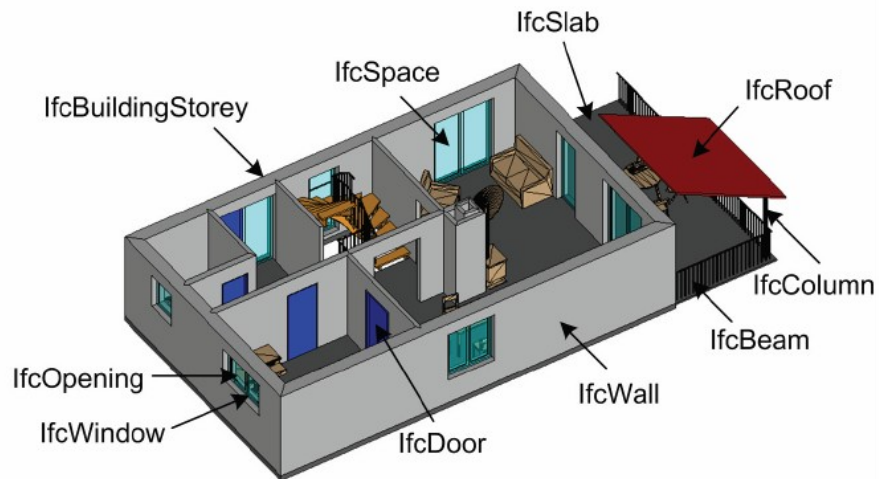
3D GIS (e.g., CityGML)

Boundary Representation

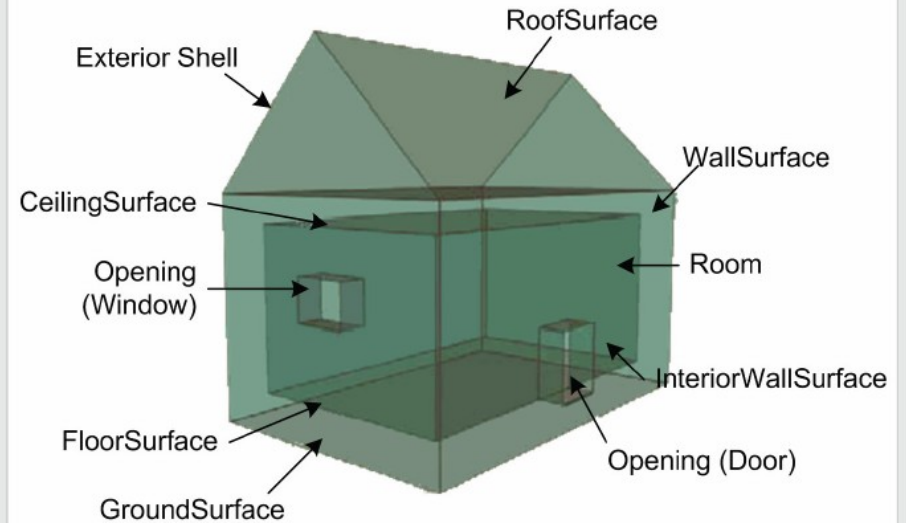


Accumulation of observable surfaces of topographic features

Element-based volume model (IFC)

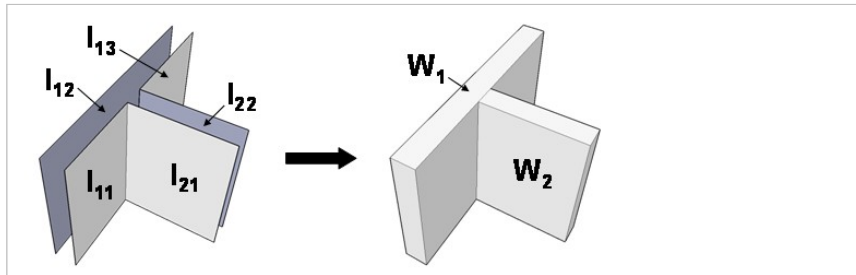


Surface model (CityGML)

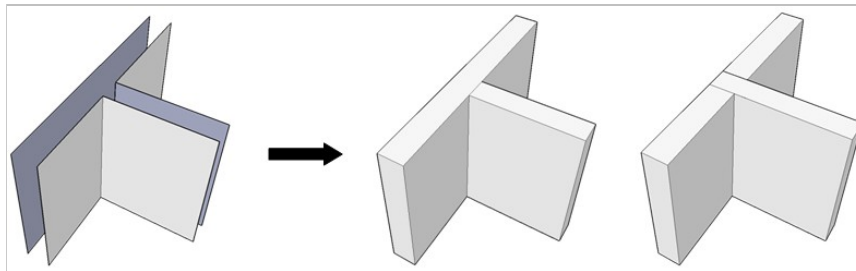


Matching between CityGML and IFC Entities

- Generation of IFC element hypotheses from CityGML entities
 - Semantic information as a priori knowledge
 - Evaluation of geometric-topological relations between CityGML entities
- n CityGML entities may represent **one** IFC element



- n CityGML entities may result in m competing IFC elements



- Further **1:1** and **1:m** relations possible
→ **High combinatorial complexity**

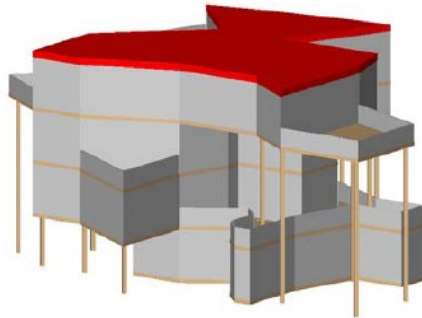
Target: Multi LoD CityGML Model

CityGML



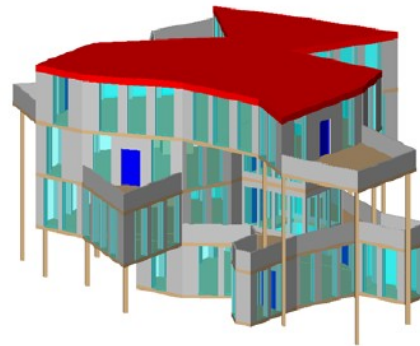
LoD 1 Model

File size: 0.02 MB



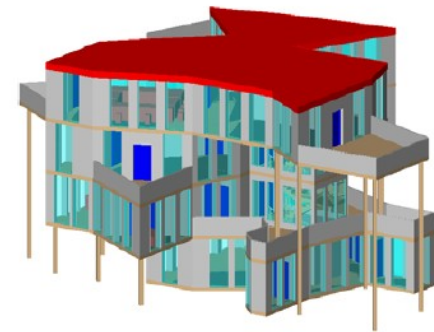
LoD 2 Model

File size: 0.7 MB



LoD 3 Model

File size: 4.9 MB



LoD 4 Model

File size: 8.7 MB

Past work

- *Mostly* focussed on conversion of geometry
- *Mostly* focussed on down-grading IFC to lower LOD's CityGML
- Interest for the rich semantics of IFC

Our goal:

- Extending CityGML with the rich semantics of IFC

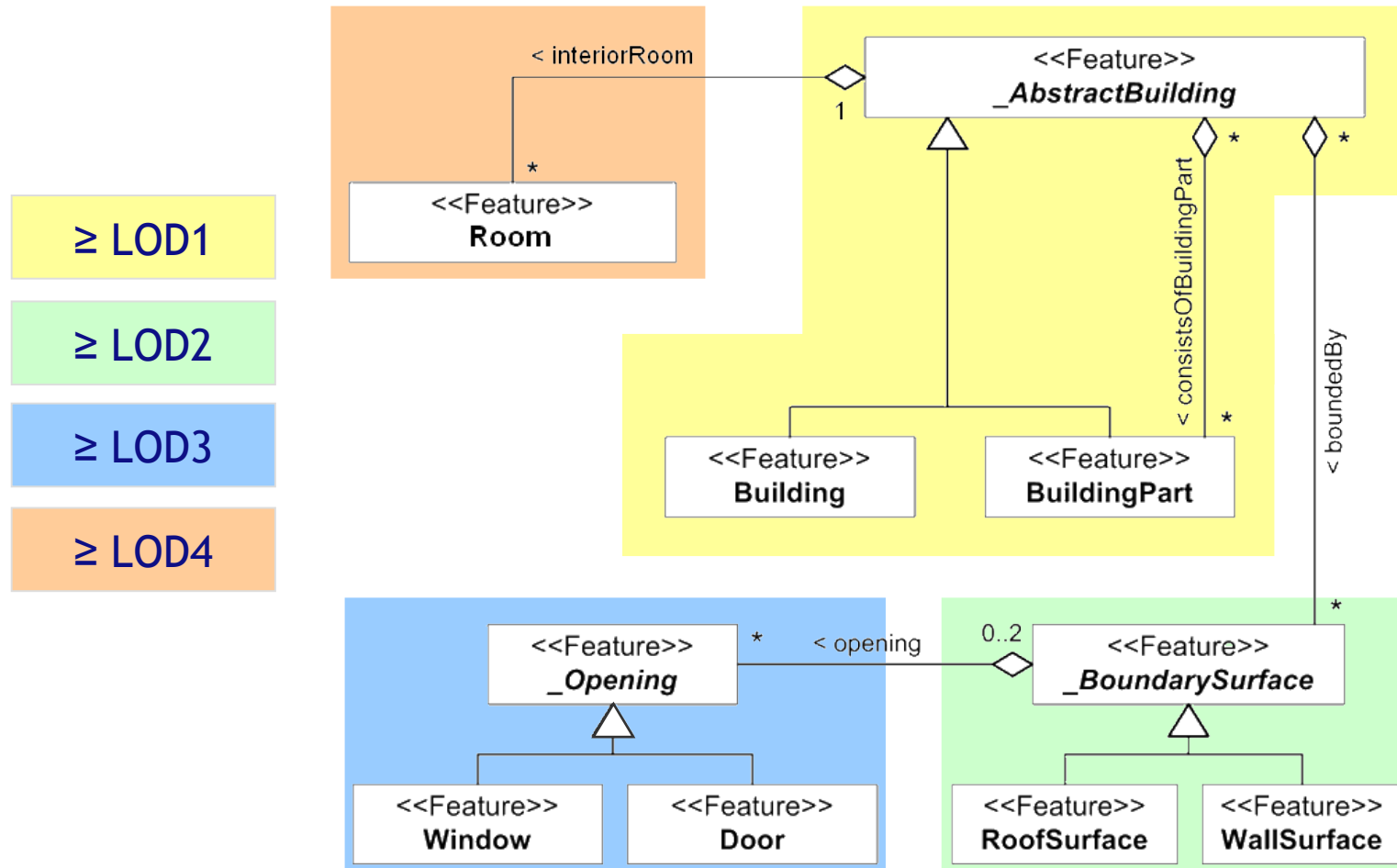
Extending CityGML with ADE

- **Noise**
- **Subsurface Structure**
- **Bridge**
- **BIM/IFC**
- **CAFM**
- **Hydro**

The BIM / IFC - ADE

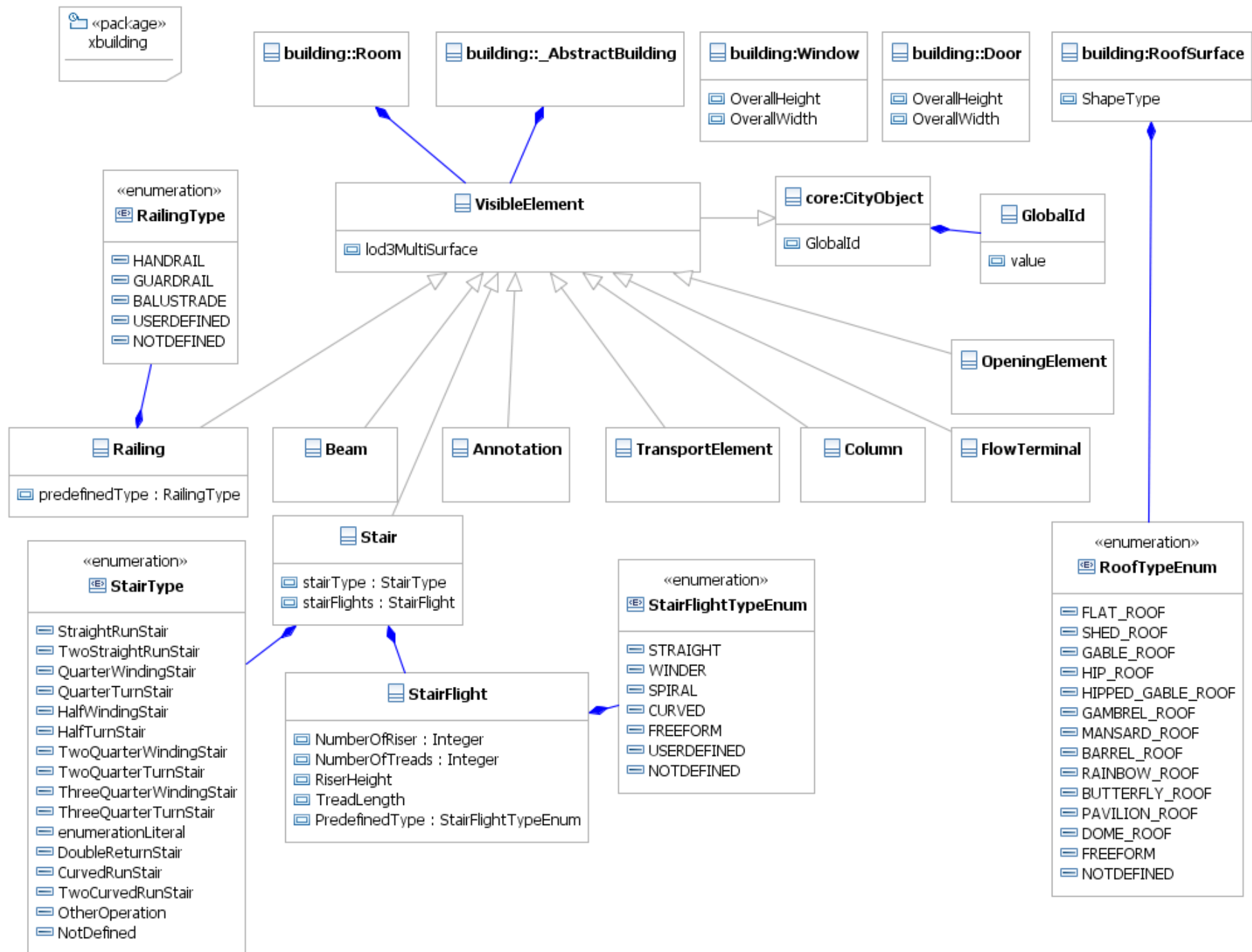
- Extending Room, Window, Door, Opening, Buildingfurniture, BuildingInstallation, IntBuildingInstallation, Building and BuildingPart with extra (IFC)-properties.
- Extending “_AbstractBuilding” with extra properties
- Extending “_AbstractBuilding” with extra classes (and prop.)
- Focus on *adding* details (in stead of downscoping)
- Thought of adding a LOD5 (didn't do it because of viewer comp.)

CityGML: Levels Of Detail (LOD) concept



The IFC classes to squeeze in the ADE:

- IfcAnnotation
- IfcBeam
- IfcBuilding
- IfcBuildingElementComponent
- IfcBuildingElementPart
- IfcBuildingElementProxy
- IfcBuildingStorey
- IfcChamferEdgeFeature
- IfcColumn
- IfcCovering
- IfcCurtainWall
- IfcDiscreteAccessory
- IfcDistributionChamberElement
- IfcDistributionControlElement
- IfcDistributionElement
- IfcDistributionFlowElement
- IfcDistributionPort
- IfcElectricalElement
- IfcElectricDistributionPoint
- IfcElementAssembly
- IfcEnergyConversionDevice
- IfcEquipmentElement
- IfcFastener
- IfcFooting
- IfcGrid
- IfcMechanicalFastener
- IfcMember
- IfcOpeningElement
- IfcPile
- IfcPlate
- IfcProjectionElement
- IfcProxy
- IfcRailing
- IfcRamp
- IfcRampFlight
- IfcReinforcingBar
- IfcReinforcingMesh
- IfcRoof
- IfcRoundedEdgeFeature
- IfcSite
- IfcSlab
- IfcSpace
- IfcStair
- IfcStairFlight
- IfcStructuralCurveConnection
- IfcStructuralCurveMember
- IfcStructuralCurveMemberVarying
- IfcStructuralLinearAction
- IfcStructuralLinearActionVarying
- IfcStructuralPlanarAction
- IfcStructuralPlanarActionVarying
- IfcStructuralPointAction
- IfcStructuralPointConnection
- IfcStructuralPointReaction
- IfcStructuralSurfaceConnection
- IfcStructuralSurfaceMember
- IfcStructuralSurfaceMemberVarying
- IfcTransportElement
- IfcVirtualElement
- IfcFurnishingElement
- IfcWall
- IfcWallStandardCase
- IfcWindow



Why we want to do this?!

- Getting more semantic object/data from IFC into CityGML
(Focus on extending details)
- A lot of possibilities: Energy assessment; Space management; Structural analysis; Piping and wiring; Foundations; Tunnels; Sewers;
- But: you probably all have different reasons to be in this room....
- We just thought it would be cool!
 - Or in a nice word: *possibility push*

The coding stuff and screenshots

Implementation (BIMserver, citygml4j)

- Open source BIMserver.org software
- IFC Engine DLL library
- CityGML4j
- “agile” :-S

“The ADE sucks if it can not be implemented for practical use”

Don't invent something that cannot be made
(applied research)

Some 'agile' remarks

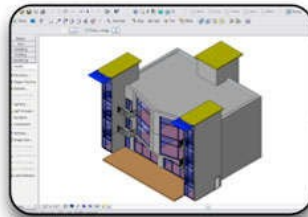
- We implemented geometry conversion IFC -> CityGML
 - Started extending the objects with IFC-specific properties
 - Started extending _AbstractBuilding with extra classes
 - Extended extra classes with extra properties
-
- So Roof, Door, BuildingPart, etc.. all have extra (IFC-specific) properties

The deal

- Get object from IFC;
- Run it through the IFC Engine DLL;
- Get triangles back;
- Get IFC properties;
- Get next object;
-
- Convert data to CityGML;

BIMserver
IFC Engine
IFC Engine
BIMserver
BIMserver

CityGML4j



CAD & BIM desktop tools



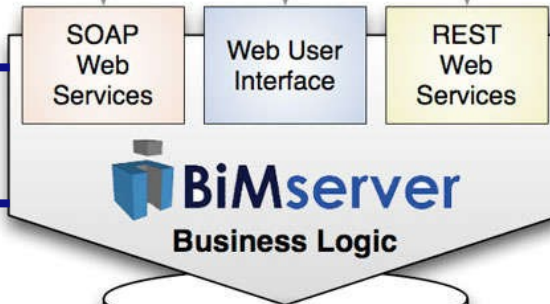
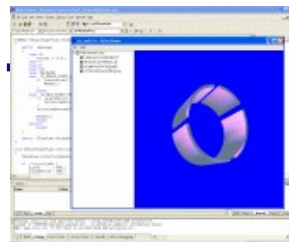
Web-based Exploration

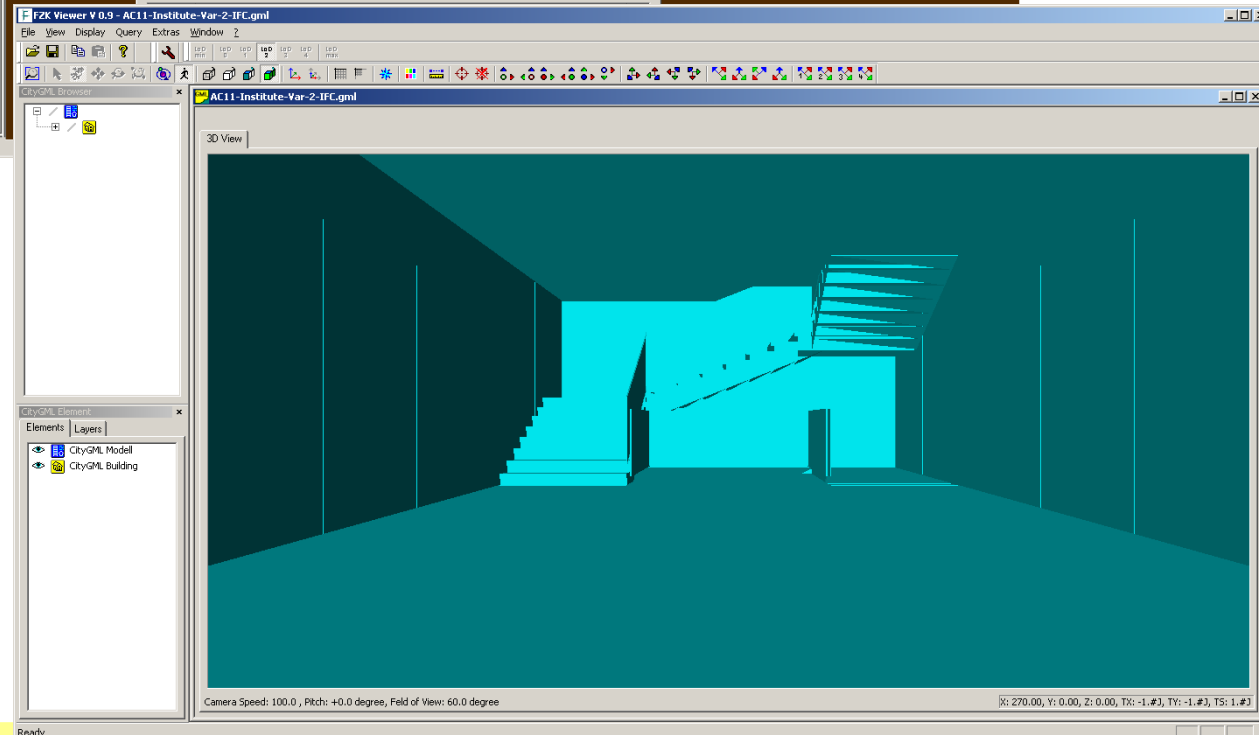
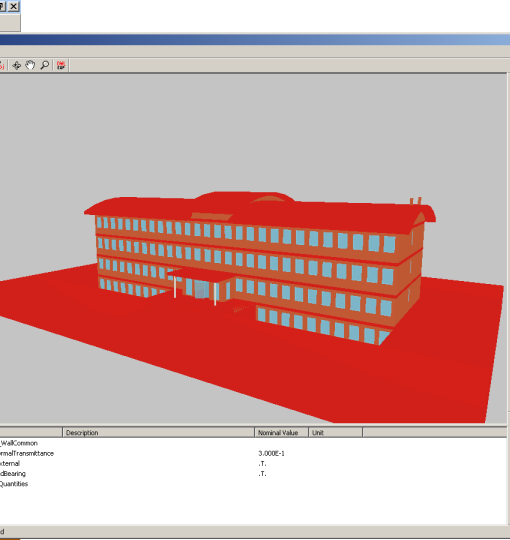
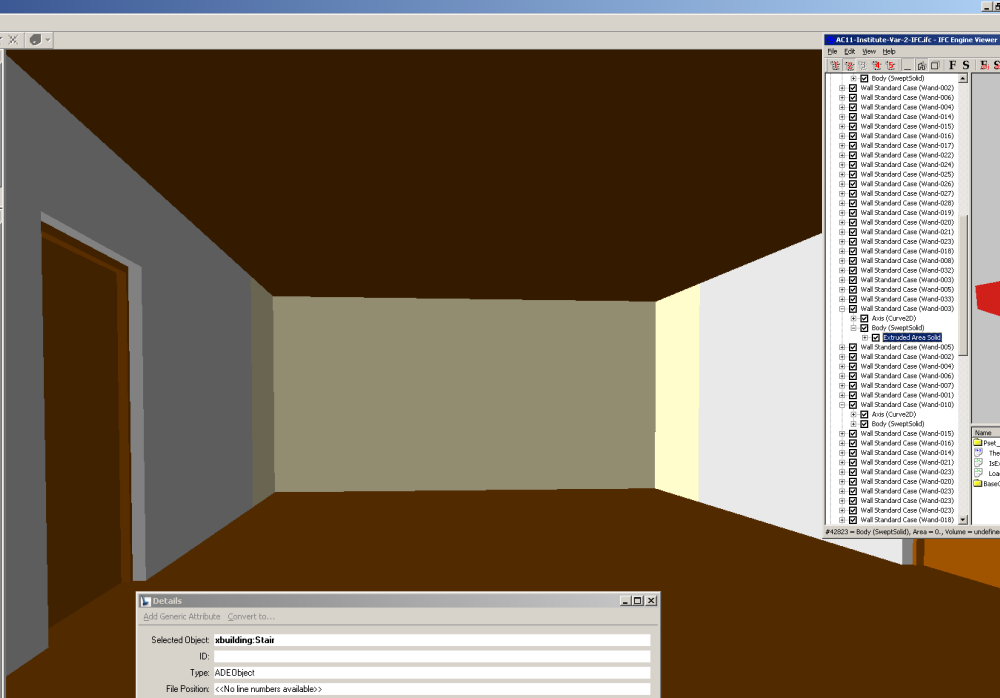


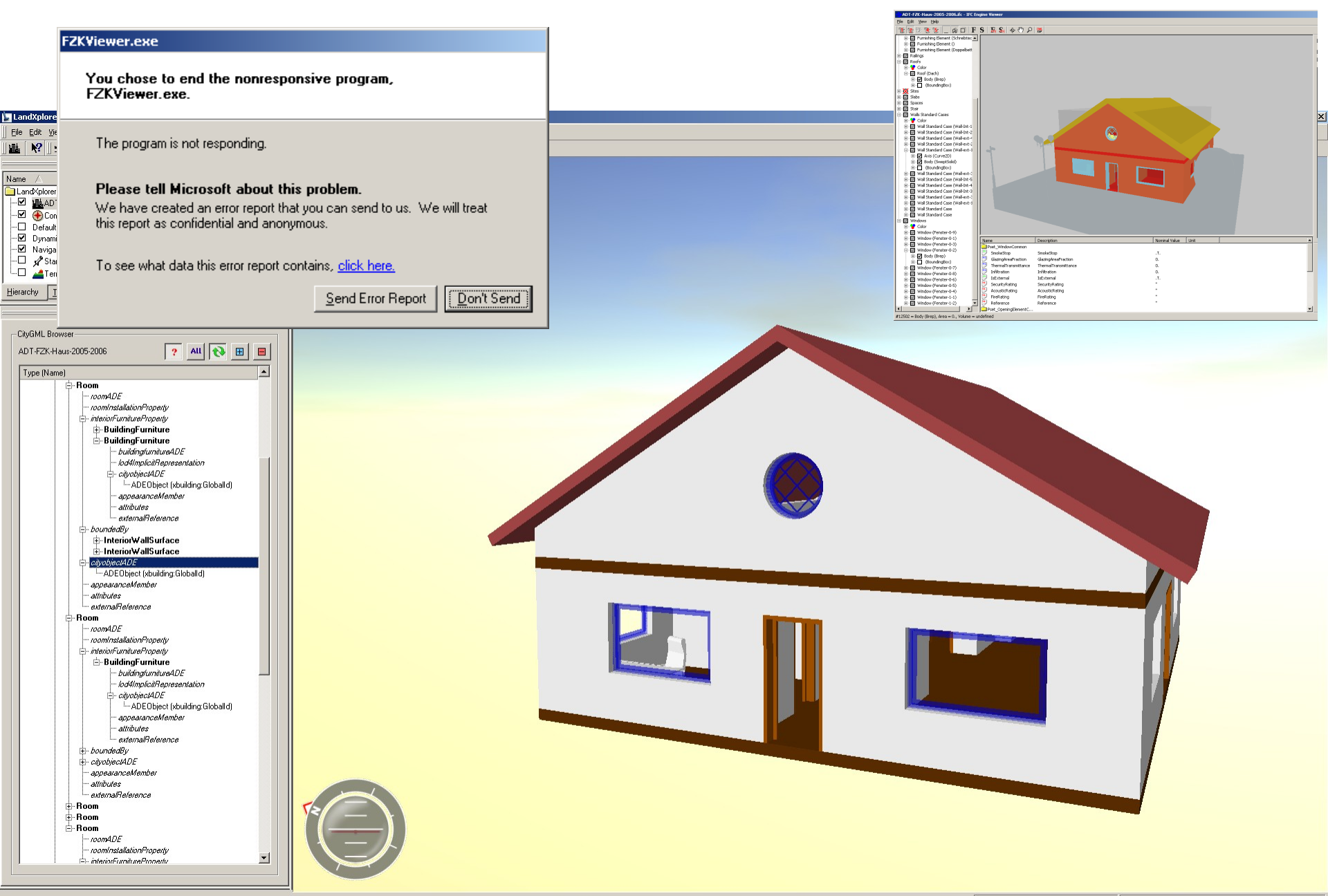
Third-party Web Services



citygml4j







FZKViewer.exe

You chose to end the nonresponsive program,
FZKViewer.exe.

The program is not responding.

Please tell Microsoft about this problem.

We have created an error report that you can send to us. We will treat
this report as confidential and anonymous.

To see what data this error report contains, [click here](#).

Send Error Report

Don't Send

CityGML Browser

ADT-FZK-Haus-2005-2006

Type (Name)

- Room
 - roomADE
 - roomInstallationProperty
 - interiorFurnitureProperty
 - BuildingFurniture
 - buildingFurnitureADE
 - lodImplicitRepresentation
 - cityObjectADE
 - ADEObject (xbuilding GlobalId)
 - appearanceMember
 - attributes
 - externalReference
 - boundedBy
 - InteriorWallSurface
 - InteriorWallSurface
 - cityObjectADE
 - ADEObject (xbuilding GlobalId)
 - appearanceMember
 - attributes
 - externalReference
- Room
 - roomADE
 - roomInstallationProperty
 - interiorFurnitureProperty
 - BuildingFurniture
 - buildingFurnitureADE
 - lodImplicitRepresentation
 - cityObjectADE
 - ADEObject (xbuilding GlobalId)
 - appearanceMember
 - attributes
 - externalReference
 - boundedBy
 - cityObjectADE
 - appearanceMember
 - attributes
 - externalReference
- Room
- Room
- Room
 - roomADE
 - roomInstallationProperty
 - interiorFurnitureProperty

[5.12654985; -0.20000000; 10.42186221] LandXplorer CityGML Viewer - v2009.0.0.14356 [2008-11-11]



The beauty part:

Download this stuff for yourself at <http://foss4g.bimserver.org>

The final words...

Conclusions

- A bit early for conclusions.....
- **It is possible!**
- There are a lot (maybe too much?) data in just one file
- Maybe split semantics and geometry?
and/or make CityGML service/server-based?
(using zoom levels and maybe even caching like in WMS?)

Issues

- Geometry issues (see presentations of the heroes)
- Not displaying ADE geometry in Landexplorer (?!)
- File size issues (detailed geometry in XML just doesn't work out)
- Direction of geometry (Surface normals)
- No network structure in CityGML (like piping)
- Lot of different ways to link objects in IFC (no hierarchy)
- CityGML4j not supporting everything we want (?)
-

Future ambitions

- Too much to put in one sheet....
- Please inspire (and sponsor) us!

More info:

- http://www.citygmlwiki.org/index.php/CityGML_BIM_ADE
- <http://www.bimserver.org>
- <http://www.tno.nl>
- Try for yourself:
<http://foss4g.bimserver.org>



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