INVESTIGATING INTEROPERABILITY CAPABILITIES BETWEEN IFC AND CITYGML LOD 4 - RETAINING SEMANTIC INFORMATION

National Technical University of Athens (NTUA) 
University College London (UCL)

Authors: Georgios S. Floros, Claire Ellul and Efi Dimopoulou

Netherlands, October 2018
Structure

Research Questions

CityGML & IFC

Literature Review

Method

Case Study

Results

Discussion

Conclusions & Future Work
Research Questions

- How do we facilitate a conversion from IFC to CityGML LoD 4?
- How can a BIM model be created in order to best enable downstream use in CityGML LoD 4?
- To what extent can the conversion process be automated, while preserving and transferring both semantic and geometric information?
CityGML

- Storage and exchange of a 3D City Model
- 5 Levels of Detail (LoD 0-4)
  - CityGML Building
  - CityGML Extension

Industry Foundation Classes

- Detailed Representation of IFC Building
- Level of Development 100-500
  - IFC Extension

Sources:
Building SMART International, 2007
Open Geospatial Consortium, 2012
## Integration method

<table>
<thead>
<tr>
<th>Integration method</th>
<th>Advantages</th>
<th>Challenges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unidirectional approach</td>
<td>Successful geometry conversion</td>
<td>Requirement for semantic preservation</td>
</tr>
<tr>
<td></td>
<td>Time-efficient</td>
<td>Generation of valid LoD 4 CityGML models</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Generation of lower LoDs from a LoD 4 Model</td>
</tr>
<tr>
<td>CityGML Extension</td>
<td>Efficient solution of integrating data in terms of geometry and semantics</td>
<td>Offering solution for a specific application field</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wasteful in terms of time and money</td>
</tr>
<tr>
<td>3rd party system</td>
<td>Efficient data integration</td>
<td>Offering solution for a specific application field</td>
</tr>
</tbody>
</table>
Utilize ETL technology via FME

- Challenging task
- Semantic Preservation
- Flexibility of the process
- Basis for bidirectional approaches
Method (2/2)
Case Study

Software & Tools

- AutoCAD Civil 3D 2017
- Autodesk Revit 2017
- Enterprise Architect 2017
- Feature Manipulation Engine (FME) 2017
- FZK Viewer
- qGIS 2.14
- Trimble SketchUp 2017
BIM in Revit

- Georeference of the model
- Setting Element Views
- Model Generation
- Semantic Enrichment & Properties
- IFC Model
IFC -> CityGML (1/4)

Geometric conversion in Trimble SketchUp
IFC -> CityGML(2/4)

Geometric conversion in FME Workbench
# IFC -> CityGML (3/4)

## Semantic Mapping

<table>
<thead>
<tr>
<th>IFC Entity</th>
<th>CityGML Mapping</th>
<th>CityGML LoD Name</th>
<th>Feature Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ifc Building</td>
<td>CityGML Building</td>
<td>LoD4MultiSurface</td>
<td>CityObjectMember</td>
</tr>
<tr>
<td>Ifc Door</td>
<td>CityGML Door</td>
<td>LoD4MultiSurface</td>
<td>Opening</td>
</tr>
<tr>
<td>Ifc FurnishingElement</td>
<td>CityGML BuildingFurniture</td>
<td>LoD4MultiSurface</td>
<td>Building Furniture</td>
</tr>
<tr>
<td>Ifc Railing</td>
<td>Outer</td>
<td>LoD3Geometry</td>
<td>outerbuildinginstallation</td>
</tr>
<tr>
<td></td>
<td>Interior</td>
<td>LoD4Geometry</td>
<td>intbuildinginstallation</td>
</tr>
<tr>
<td>Ifc Slab</td>
<td>Roof</td>
<td>LoD3MultiSurface</td>
<td>bounded by</td>
</tr>
<tr>
<td></td>
<td>Ground</td>
<td>LoD3MultiSurface</td>
<td>bounded by</td>
</tr>
<tr>
<td></td>
<td>Ceiling</td>
<td>LoD3MultiSurface</td>
<td>bounded by</td>
</tr>
<tr>
<td></td>
<td>Floor</td>
<td>LoD3MultiSurface</td>
<td>bounded by</td>
</tr>
<tr>
<td></td>
<td>ClosureSurface</td>
<td>LoD3Geometry</td>
<td>bounded by</td>
</tr>
<tr>
<td></td>
<td>Landing slab-Out</td>
<td>LoD3Geometry</td>
<td>bounded by</td>
</tr>
<tr>
<td></td>
<td>Landing slab-Int</td>
<td>LoD3Geometry</td>
<td>bounded by</td>
</tr>
<tr>
<td>Ifc Space</td>
<td>Room</td>
<td>LoD4MultiSurface</td>
<td>interiorRoom</td>
</tr>
<tr>
<td>Ifc Stair</td>
<td>Outer</td>
<td>LoD3Geometry</td>
<td>outerbuildinginstallation</td>
</tr>
<tr>
<td></td>
<td>Interior</td>
<td>LoD3Geometry</td>
<td>intbuildinginstallation</td>
</tr>
<tr>
<td>Ifc Stairflight</td>
<td>Outer</td>
<td>LoD3Geometry</td>
<td>outerbuildinginstallation</td>
</tr>
<tr>
<td></td>
<td>Interior</td>
<td>LoD3Geometry</td>
<td>intbuildinginstallation</td>
</tr>
<tr>
<td>Ifc WallStandardCase</td>
<td>Wall Surface</td>
<td>LoD3MultiSurface</td>
<td>bounded by</td>
</tr>
<tr>
<td></td>
<td>Interior WallSurface</td>
<td>LoD3MultiSurface</td>
<td>bounded by</td>
</tr>
<tr>
<td>Ifc Window</td>
<td>Window</td>
<td>LoD4MultiSurface</td>
<td>Opening</td>
</tr>
</tbody>
</table>
Semantic Preservation
Results: CityGML LoD 3-4 Model 1
Results: CityGML LoD 3-4 Model 2
Results: Semantic Preservation (1/2)

Generic Attributes & Properties (Model 1)
Results: Semantic Preservation (2/2)

Generic Attributes & Properties (Model 2)
Discussion

BIM to CityGML LoD 4

- Semantic differences in vertical surfaces
- Components of an object stored in multiple IFC Entities
- Different boundaries of IFC Slabs

Semantics & Automation

- Sufficient coverage of CityGML Building features
- Capability to tackle geometric and semantic errors
- Scaling difficulty and automation from LoD 3 to LoD 4
- Alteration of the workflow is necessary
Conclusions

- Generation of CityGML LoD 4 Models using ETL
- Utilization of multiscaling modelling
- Preservation of CityGML Semantics
- Enrichment of the CityGML Model with IFC semantics

Purpose: Utilize semantic preservation!!!

- Complicated process
- Common surfaces
Future Research Work

- Type of information in BIM for specific applications
- Structure in BIM to comply with CityGML Standard
- Reduce manual intervention
- Investigate topology issues in LoD 4
- Generating lower LoDs from higher LoDs
- New BIMs-New potential challenges
Thank you for your attention!!!