Abstract

"Smart cities" is a relatively new scientific field, applied to an increasing number of application fields. This evolution though, urges data collection and integration, hence major issues arise that need to be tackled. One of the most important challenges is the heterogeneity of collected data, especially if those data derive from different standards and vary in terms of geometry, topology and semantics. Another key challenge is the efficient analysis and visualization of spatial data, which due to the complexity of the physical reality in modern world, 2D GIS struggles to cope with. So, in order to facilitate data analysis and enhance the role of smart cities, the 3rd dimension needs to be implemented. Within this context, standards such as the CityGML and the Industry Foundation Classes (IFC) although fulfill this necessity, they present major differences in their schemas, thus rendering their integration a challenging task. On one hand, CityGML is an open standard that stores and represents information of the entities that can be addressed in a modern 3D city model, while on the other hand IFC describes in maximum detail the construction of a building from an architectural point of view. The aim of this thesis is to investigate the integration possibilities of the aforementioned standards, starting from generating the IFC model and ending with generating a CityGML LoD 4 model, able to preserve its semantic information and be further extended with multiple attributes and properties.

The 1st step of the methodology is the development of the prototype models in BIM, which represent real-world objects. The modelling procedure is presented and analyzed with respect to the key differences that can be noticed between IFC and CityGML in terms of geometry and semantics. Within this context, information that are critical for the correct mapping of semantics are extruded and utilized in the stage of conversion and enrichment. By generating the IFC model there is an opportunity to investigate common errors that might be included in a model such as overlapping surfaces and develop a conversion algorithm that is able to tackle them efficiently.

Secondly, follows the conversion of IFC to CityGML LoD 4 model by implementing Extract Transformation Load (ETL) process. The entities of the IFC model are extracted and manipulated separately. The process is divided in two stages: geometric correction and semantic mapping. With regard to the geometric correction, it is further sub-divided in geometry processing inside FME Workbench and geometry processing in Trimble SketchUp. Semantic mapping occurs inside FME Workbench and complies with the CityGML principles. The CityGML LoD 4 model is generated and evaluated both geometrically and semantically. Then, the preservation of semantics is investigated. The type of semantics that are taken into consideration in this thesis are: (i) general semantic information that exists in every IFC model, (ii) semantic information with respect to the texture and material of each boundary surface that can be implemented for energy management purposes and (iii) semantics that contain attributes and properties with respect to the legal and

cadastral aspect of a 3D model. The aforementioned semantic types can be located in multiple CityGML features. More specifically, the material surface refers to the boundary surfaces of the model, the generic semantics refer to components and boundary surfaces of the model and legal information refer to the interior "free space" of the model. The last step of the developed methodology involves the transfer of the preserved semantics to the CityGML model. This is feasible either via (i) Generic objects and attributes or (ii) CityGML ADEs. Both methods are investigated and the results are clearly presented.

Lastly, an evaluation of the overall process takes place, in response to the research questions. Additionally, conclusions and general remarks regarding the advantages and disadvantages of the presented methodology are presented. The complexity of the process allows for future research work included in 3D modelling, data conversion and model extension. Concluding remarks for both standards are briefly presented in the final part of this thesis.