IFC to CityGML Transformation Framework for Geo-Analysis: A Water Utility Network Case

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INTRODUCTION

The development of semantic 3D city models has allowed for new approaches to town planning and urban management (Benner et al. 2005) such as emergency and catastrophe planning, checking building developments, and utility networks.

Utility networks inside buildings are composed of pipes and cables located between ceilings and walls (examples of these systems include sewerage, electrical, gas, water). The traditional representations of these networks are in 2D, and are associated with different drawbacks, such as the overlapping of lines representing different networks, and different vertical elements (which can be represented only as points) can be missing (Du and Zlatanova 2006). Moreover, topological analyses are not possible by using this 2D geometric representation. Therefore, interest in 3D representation of such infrastructures is rapidly increasing.

The purpose of incorporating utility networks into GIS is for modelling them topologically rather than geometrically. Geospatial analysis of such utility network systems requires the path and point connections of the elements, instead of their geometry. On the other hand, the CAD/BIM systems offer a rich 3D geometrical representation. Developing a system that supports both CAD/BIM and GIS capabilities is still not feasible, and thus the best approach to concentrate on is CAD/BIM-GIS interoperability at the data level (Wu and Hsieh 2008). Detailed geometric information about utilities infrastructure can be obtained from design and real-world 3D CAD/BIM models, which could be automatically exchanged if a formal framework, would be made available.

In this paper, we investigate the possibility of integrating the 3D BIM utilities network data into a GIS based on user cases defined for water utilities maintenance operations and management. CityGML has been employed in this study as a base model to provide an integrated ontology covering the BIM and GIS model concept within one framework. The work includes developing a software component for automatic conversion from

IFC into CityGML, and analysing network elements in an already developed system that supports utilities analysis functions.

BACKGROUND IN IFC/CITYGML INTEROPERABILITY

There is an increasing interest in addressing interoperability and interaction between 3D BIM and 3D GIS data (Isikdag et al. 2008). The two prominent semantic models in the building design and 3D GIS are IFC and CityGML (Isikdag and Zlatanova 2009). IFC data model has become an international industry standard for AEC data exchange and sharing. IFC has been designed and developed to define objects with geometrical and semantic information (BuildingSmart, 2009). IFC represents not only tangible building components, such as walls, doors, beams, etc, but also an abstract concept, such as schedules, activities, construction costs, etc. On the other hand, CityGML (as an OGC standard) provides a specification for the representation of the 3D urban objects, including buildings (CityGML, 2009). Until today a certain amount of work has been carried out on the integration of CAD/GIS and IFC/GIS. Two approaches have been employed: either to transfer geo-data from GIS to CAD/BIM; or to transform CAD or BIM data into GIS. IFG was one of the first efforts for the integration of IFC models with GIS (and geospatial models). In another effort Benner et al. (2004) proposed the QUASY object data model, which is a 3D semantic building model for urban development. The authors also developed a tool for automatic generation of semantic building models based on IFC-models. Wu and Hsieh. (2007) presented an algorithm for automatic conversion of IFC to GML. The algorithm works only on the transformation from swept solid models to the B-Rep. Isikdag and Zlatanova (2008) provide preliminary ideas for defining semantic mapping between the IFC data model and CityGML. The purpose of their work was to allow automatic transformation between the two models. In another study, Isikdag et al. (2008) have investigated the possibilities of automatic conversion from IFC to GIS based on two case studies: fire response and site selection. Their research includes a description of a developed tool for automatic conversion from IFC to ESRI shapefile and GeoDatabase.

The focus of the transformation methods presented in the above studies considers only the building's architectural elements, such as walls, spaces, door, etc. To our knowledge, there is no systematised study on enabling interoperability between IFC and CityGML for utility networks.

A building can contain installations such as interior stairs, railing and pipes, etc, which are represented by IntBuilding Installation class at City GML LOD 4 (BuildingSmart 2009).

The IFC schema has different entities that can support the GIS utility network application. Primary analysis shows that the following sub-schemas

- IFCBUILDINGCONTROLSDOMAIN,
- IFCPLUMBINGFIREPROTECTIONDOMAIN,
- IFCSHAREDBLDGSERVICEELEMENTS

Contain the entities representing the different objects of the network, such as pipes/ ifcFlowsegment, shut-off valve/ IfcFlowController, etc.

ONGOING WORK AND OUTLOOK

An important step in this study is the clarification of the use case. Until today, several meetings with mechanical office staff in the University of Osnabrueck have been held. The purpose was to get to know their responsibilities and operational workflow. Two scenarios have been defined until now. One of them is to improve regular inspection of the water utilities to ensure the cleanliness of the system, and the other is related to maintenance operation (either planned or in response to campus community emergencies or failures in the network).

Based on the above-described scenarios, we are currently in the process of investigating the entities (elements) of the IFC model which contain information that should be mapped into the CityGML. The investigation also includes looking for the possibilities of preserving the topology in the utility networks in addition to the geometry.

Future work will include developing an IFC parser that allows the automatic elicitation of the information in parallel with the requirements of the use case and converting it to CityGML. The information that will be transferred by the IFC parser will also be integrated into the water utility applications that we have developed based on open-source software and specifications. The system contains the functions that are required to perform topological analysis on a utility networks such as trace up stream, down stream, etc. (see Figure 1)

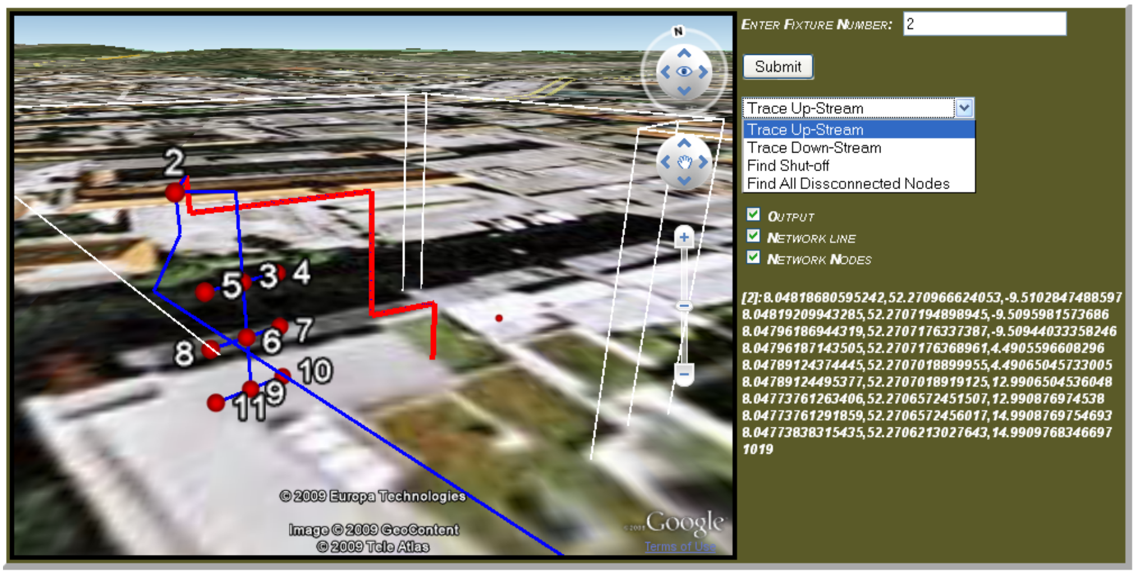

Fig 1: Water Utility network application

EXPECTED RESULTS

The work should provide initial understanding for building a formal framework for the geometric and semantic transformation of utilities infrastructure inside buildings between the two data models, IFC and CityGML. To demonstrate the applicability of the developed framework, a number of trial conversions will be carried out between IFC and the CityGML models, the conversion will be performed using the tool that will be developed.

Moreover, the work will demonstrate a new possible application for infrastructure analysis that includes interior space. The prototype capabilities will allow us to answer questions such as: which rooms inside the building will be out of service in case of maintenance operation (on which basis notification emails will be sent to the room occupants), or where the shut-off valve can be found in case of emergency or reported failure.

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