INTEROPERABILITY BETWEEN GIS AND BIM
A Semantic-based Multi-representation Approach

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Abstract: Interoperability of information systems is partially resolved due to many standards such as networks protocols, XML derived languages and object oriented programming. Nevertheless, semantic heterogeneity limits collaborative works and interoperability. Despite ontology and other semantic technics, the binding of heterogeneous information systems requires new technics of managing and displaying information according to the semantic representation of each stakeholder of the collaboration. In this paper we addressed the problem of merging geographical information systems and building information model. The way to achieve this goal must solve several heterogeneity problems due to the data life cycle, the data temporality, the binding between 2D geo-referenced modelling and 3D geometric models or problem of scalability for real-time 3D display from remote server for managing a real environment of several million m2. To bridge this gap, we present a new architecture based on a semantic multi-representation of heterogeneous information.

1 INTRODUCTION

Today, at a time when environmental issues are becoming more insistent, ways to control costs in the management and development of a territory are increasingly sought. This may involve the facility management of a set of building block, that one wishes to identify and observe to limit the costs of maintenance or the creation of new entities in order to anticipate the ecological impacts and economic, and at different levels. These goals require to have a lot of heterogeneous information on assets to manage, at several moments of their life cycle and at different levels. This unification is an expensive process which is not always adapted to the trends of the trade or the market. The global information system becomes quickly obsolete and unsuited regarding the data model evolutions and improvements. In order to unify and centralize the management of real estate, urban and extra urban, it is necessary to develop a new form of collaborative architecture (Döllner et al., 2007). This architecture will allow to combine in a homogeneous environment a set of heterogeneous information from diverse information systems such as those from the BIM domain and the GIS domain.

The term BIM (Building Information Modeling) has been coined recently to demarcate the next generation of Information Technologies (IT) and Computer-Aided Design (CAD) for buildings which focus on drawing production. BIM is the process of generating, storing, managing, exchanging and sharing building information in an interoperable and reusable way (Vanlande et al., 2008). A BIM system is a tool that enables users to integrate and reuse building information and domain knowledge throughout the building lifecycle (Campbell, 2007). The Geographic Information Systems (GIS) are becoming a part of mainstream business and management operations around the world in organizations, both in public and private sectors, as diverse as cities, state government, civil engineering, telecommunications, urban planning, petroleum exploration, land surveying, etc... The term GIS refers to any system that captures, stores, analyzes, manages, and presents data that are linked to at least one location. BIM and GIS need to be coupled in a common environment in an interoperable way.

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Since 2008, as part of a European project, we develop a collaborative web platform dedicated to urban facility management. Our Urban Information Model (UIM) approach combines both BIM and GIS using semantic modelling to access global knowledge of a complete urban environment, including sets of buildings and urban objects that compose this environment. This approach is based on a semantic architecture using ontology evolution mechanisms (Gruber, 1993). We have developed a specific 3D-viewer making possible semantic management of Level of Details (LoDs) according to user profile and context. The multi-representation introduced in our architecture adds to the traditional LoD the notion of Contextual LoDs (C-LoDs). A C-LoD is not only displayed depending on the distance between the view point and the object as it is usually the case. The representation is chosen according to other criteria that depend on user (like the business process to which he is attached), external criteria as day/night or weather, or even of the object itself. The semantic management drives streaming processes which extract the semantic and 3D representations of urban objects from a relational database.

2 SIGA3D OVERVIEW

Our proposal is based on a semantic architecture articulated in 6 levels (Figure 1). The import/export level is dedicated to the parsing of various file formats required to model the UIM from different sources (GIS/BIM). The data model level makes it possible the combination of geometrical data and semantics. The level "contextual view" associates user profiles and business rules to build contextual LoDs. The connection level is mainly dedicated to the streaming process between the databases and the interface. The interface level displays the urban environment into a 3D digital mock-up coupled with a semantic tree of urban elements.

The innovative part of this architecture is mainly contains in the data model level and contextual views level. This part is the base of our semantic LoD proposal. The first data model level part is architecture of graphs representing the ontology, allowing the context management and versioning of the data (CMF for Contextual Model Framework). Graphs operators are also defining to facilitate the implementation of changes in conceptualization.

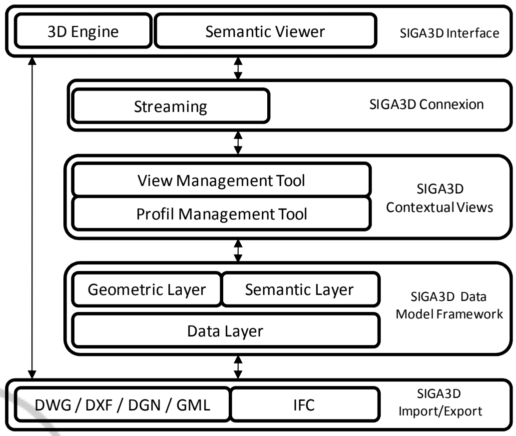

Figure 1: SIGA3D Architecture.

Information about reference systems for space and time (CRS and TimeZone) are also managed in this part. The other part defines a unified syntax-based knowledge representation based on the languages OWL, RDFS, and rules RuleML, SWRL and described in this document in an expressive way with description logic. It is called DMF (Data Model Framework). DMF also contains operators for the management of space and time and the definition of local contexts that allow us to conduct a multi-representation of data. The goal of this part is to provide models used in inference engine to infer and to check the data modelled by the CDMF modelling operators.

3 DATA MODEL FRAMEWORK

The Data Model Framework is made of operators to construct urban data models. These operators allow the description of classes and properties that can be used to define complex concepts using operators of intersection, union, involvement, etc ...

The spatial data and especially georeferenced coordinates do not make sense without the knowledge of the coordinate reference system. This information will appear in the next layer of our architecture that manages the context of model graph, to unify the management of coordinates. The same kind of information is provided for time, with the management of Time zones (Gutierrez et al., 2007).

The management of local contexts, which allows multi-representation, is done in this part by defining new stamped operators, corresponding to the dmf operators defined above. For example, script 1 defines three local contexts, *designer*, *structureEngineer* and *achievementDate*. Script 2 defines several properties and a spatial representation for a class '*buildingPlan*' which depends of the user. The contextual operators *dmf:[*c_1*, ...,*c_n *]Class, dmf:[*c_1*, ...,*c_n *]property* and *dmf:[* c_1*, ...,*c_n*] spatialEntity* are used.

```
   <dmf:Class rdf:ID='Profession'/>
   <Profession rdf:ID='designer'/>
   <Profession rdf:ID='structureEngineer'/>
   <dmf:temporalEntity rdf:ID='Day'/>
   <dmf:property rdf:ID='unitType'/>
   <Day             rdf:ID='March'><unitType
rdf:resource='#unitMonth/></Day>
```

Script 1: Definition of three local contexts.

```
   <dmf:Class rdf:ID='BuildingPlan'/>
   <dmf:[designer]property
rdf:ID='line_thick'/>
   <dmf:[structureEngineer]property
rdf:ID='wall_material'/>
   <dmf:[designer]property
rdf:ID='contains_plan'/>
   <dmf:[designer,structureEngineer]property
rdf:ID='contains_plan'/>
   <dmf:spatialEntity rdf:ID='the_plan'/>
   <dmf:[designer]property
rdf:ID='3D_plan'/>
   <dmf:[designer,structureEngineer]property
rdf:ID='2D_plan'/>
   <the_plan rdf:ID='plan_of_building_1'>
     <url_2D_plan
rdf:resource='/building/1/plan/plan2D.dwg'/>
     <url_3D_plan
rdf:resource='/building/1/plan/plan3D.ifc'/>
   </the_plan>
   <dmf:[designer,March]Class
rdf:ID='Plan_availability'/>
   <BuildingPlan rdf:ID='building_plan_1'>
       <line_thick
rdf:dataType='&xsd;float'>10</line_thick>
       <wall_material
rdf:dataType='&xsd;float'>wood</wall_materia
l>
       <contains_plan
rdf:resource='the_plan'/>
   </BuildingPlan>
```

Script 2: Example of contextual operators.

This example describes an object, *BuildingPlan*, which has several properties. For a designer, the *BuildingPlan* is defined with a *line_thick*, a *plan* containing two representations. The same object is defined differently for a structure engineer, with the material of walls, *wall_meterial*, and an attached plan with only one 2D representation.

4 CONTEXT MODEL FRAMEWORK

This part of our architecture is composed of three main blocks. The first block sets the context for each graph of DMF, the second block defines a set of graph operators to facilitate the writing and limit the redundancy of data in the context management and the third block defines a set of operators on graphs to describe more accurately the geographical information by defining relations between the spatio-temporal data models of DMF. Context management in this architecture is done by defining a special graph called *SystemGraph*. A *SystemGraph* is a graph or a set of graphs using operators. These operators are graphs of the second block of the CMF. The use of these operators can simplify the management of the evolution of knowledge of the model. So, rather than storing for each modification of the model a new version of the information, the CMF layer store the modification as operations on graphs. The *SystemGraph* can be describing using the following operators:

cdmf:graph connects graph and data. These data are described according to the data model. They can be a combination between other graphs using the CMF graph operators *AddGraph* (union of graphs), *RemoveGraph*, *InterGraph*, *CompInterGraph* and *MapGraph*
cdmf:of represents the context. This property defines a list of resources representing the access context.
cdmf:model defines for a system graph the data model which is used. This data model defines elements which will appear in the graph.
cdmf:action defines user's rights to access the data (read/write/remove). If no action is defined in the system Graph, which means that only the visualization of the data is allowed.
cdmf :synchronizationGraph defines a list of Graph depending of a special model where we define all kind of spatial and temporal relationship between data models.
cdmf:reference_frame defines the timezone and the Coordinates Reference System (CRS) used for the data model associated to the SystemGraph. These values are valid for all data of the associated graph, even if data sources are defined in another reference system (in which case it is needed to make transformations during the displaying phase of data).

The spatio-temporal synchronization is not a common graph operator and is very specific to the description of geographical information. It allows defining the validity of a model by describing relationships with other models. It can be used in case of model evolution to assure the consistency of the global model. For example, if we define a building model and an electric power network model, it is possible to describe a topological relation between the two models to say they are spatially connected. Then, when one of the models is modified, for example to reposition the building because of a bad georeferencing, we know we have to modify the other model to keep the spatial connection relation consistent.

5 CONCLUSIONS

This paper presents an ongoing research on the definition of an Urban Modelling Architecture. This paper focus on a new mechanism of LoDs called contextual LoDs. It is the merge of classical geometric approach to define LoDs and two semantic multi-representations formalisms: the first part is based on contextual trees to define user profiles and business rules at the data model level. The second part defines local contexts to allow multi-representation at a lower level, i.e. for each objects of the model. The concept of contextual LoDs is designed to be integrated in an Urban Facilities Management (UFM) platform. It is an extension of the BIM concept for the management of urban objects. Our framework facilitates data maintenance (data migration, model evolution) during the lifecycle of an urban environment and reduces the volume of data with specific graph operators. The urban approach also implies to manage precisely the spatial and temporal dimensions that have been considered in the definition of the contextual LoDs part. This approach is based on the CityGML 1.0 (Kolbe et al., 2009) and IFC 2x3 standards.

In the figure 2, a result of the integration of IFC and GIS data (the IFC building is in red, and a couple of buildings coming from GML file are in blue) into the urban ontology can be seen.

Our future works will be to achieve the implementation of our framework for the UFM platform, including the contextual LoDs management. These works are based on our previous works on Active3d (Vanlande et al., 2008) and designed to be fully compatible with both standards: the one for geographic information (e.g. ISO/TC 211) and the second for the construction world (e.g. ISO/PAS 16739).

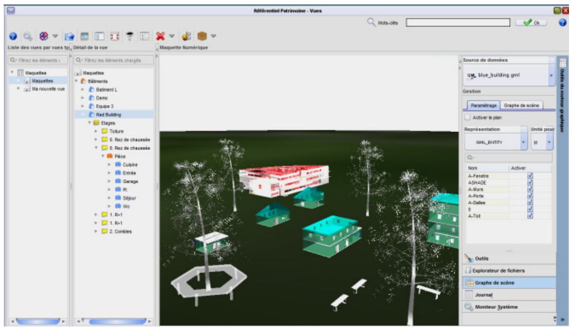

Figure 2: Example of a 3D georeferenced scene with multiple data sources.

REFERENCES

Campbell D. A., (2007), Building information modeling: the Web3D application for AEC, Published in Proceeding *Web3D '07 Proceedings of the twelfth international conference on 3D web technology, ACM* New York, NY

Döllner J., Hagedorn B (2007), Integrating Urban GIS, CAD, and BIM Data By Service-Based Virtual 3D City Models. *26th Urban Data Management Symp*., Stuttgart, Germany

Gruber, T., R. (1993), A translation approach to portable ontologies- Knowledge Acquis., 1993., pp 1-27

Gutierrez, C., Hurtado, C. A., and Vaisman A. (2007), Introducing Time into RDF. *IEEE Transactions on Knowledge and Data Engineering*, 19(2):207-218

Kolbe, T. H. (2009) Representing and Exchanging 3D City Models with CityGML, Lee, Jiyeong / Zlatanova, Sisi (Eds.), Proceedings of the 3rd Int.Workshop on 3D Geo-Information, Seoul, Korea. Lecture Notes in *Geoinformation & Cartography, Springer Verlag*, 2009

Vanlande, R., Cruz C., Nicolle C. (2008) IFC and Buildings Lifecycle Management", *Journal of Automation in Construction*, Volume 18, Issue 1, Elsevier, 2008, pp 70-78