Urban Information Modeling Combining BIM and GIS

Clement Mignard
LE2I – UMR CNRS 6306, IUT Dijon-Auxerre, Université de Bourgogne, France

Christophe Nicolle
University of Burgundy, France

INTRODUCTION

Urban Information Modeling is a relatively recent discipline enabled by the development of semantic, GIS and 3D technologies in computer science. This article introduces UIM as a combination of BIM (Building Information Modeling) and GIS-related technologies (Geographic Information Systems). In our approach, the concept of UIM is enabled by the definition of contextual information using semantic web languages. The term BIM has been recently coined in order to identify the next generation Information Technologies (IT) and Computer-Aided Design (CAD) for buildings. BIM is the process of generating, storing, managing, exchanging and sharing building information in an interoperable and reusable way. A BIM system is a tool that enables users to integrate and reuse building information and domain knowledge throughout the building life cycle (Campbell, 2007). GIS are becoming a part of mainstream business and management operations around the world in organizations, both in public and private sectors. The term GIS refers to any system that captures, stores, analyses, manages, and presents data that are linked to at least one location. By coupling these two fields of activity in a common environment, it becomes possible to manage urban facilities (including buildings and urban proxy elements) in an interoperable way. To achieve this, we use semantic graphs that allow us to define concepts and relations in order to model all the necessary information. This article focuses on the semantic and geometric modeling of urban objects.

BACKGROUND

For modeling building and geographic information, we have identified three axes of research and development (Figure 1). First, we have the BIM axis, which corresponds to the modeling of a building. Then, we have the GIS axis that represents geographic data and related tools. Finally, we have the contextual axis that represents the context related to a concept, through ontologies. In this multi-axes system, we can identify and place several solutions dedicated to the implementation of one or more fields. For example, CAD (Computer-Aided Design) software, which is used to draw buildings, can be positioned along the BIM axis. GIS-related applications, which can display 2D geo-referenced geometries, are located on the GIS axis. Then, semantic web languages, such as RDF (Resource Description Framework) and OWL (Web Ontology Language), which are used to model context, can be placed on the third axis, namely the context axis.

Several approaches are available for 2D representation of building information, including 3D GIS, which can improve the buildings' representation dimension of GIS. FM-CAD (Facility Management) from CAD editors provides some FM in order to ease the contextualization of BIM information. Similarly, we have BIM-GIS approaches from GIS editors that help modeling building information in geographic systems. Furthermore, we have solutions that allow more or less to deal with all three dimensions. These solutions are identified in Figure 1 and will be detailed in the next sections of this article.

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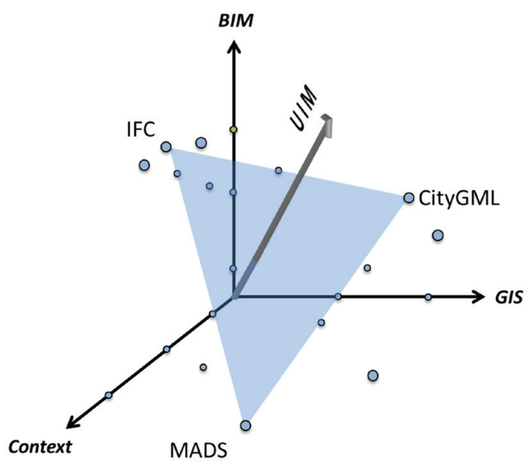
Figure 1. Axes for urban information modeling



In order to achieve interoperability among BIM and GIS, the use of standards is needed. For building information modeling, the most known and used standard is IFC (Industry Foundation Classes). As we can see in Figure 1, this approach is highly suitable for building information modeling, and allows to represent contextual and geographical data. Another standard worth mentioning is CityGML, an OGC (Open Geospatial Consortium) standard, which is specialized in dealing with geographical information, and allows some contextual information definition and building modeling. The third standard is a conceptual model for traditional & spatio-temporal applications called MADS (Modeling of Application with Spatial-temporal Data). It focuses on defining contextual mechanisms to create multiple representations for a given geographical context. This is done by defining stamps that correspond to a couple (resolution, point of view) and for which a given representation is valid. In the next sections, we will detail two of the above mentioned standards, namely IFC and CityGML.

IFC is an ISO (International Organization for Standardization) standard used for defining all components of a building as needed in a civil engineering project. The IFC forms the basis of a building description. This basis is enriched during the building's lifecycle with elements related to facility management: financial data, maintenance rules, evacuation procedures and so on. The quantity of information grows exponentially and a relevant organization of these elements is rapidly needed. IFC files are made of objects and connections between these objects. At the end of a project, the file corresponding to the IFC building contains all its elements thanks to a multi-context definition. IFC files are textual files whose size can reach 100 megabytes. The attributes for the objects describe the "business semantic" of these objects. The connections between objects are represented by "relationship elements." The IFC is an object model based on EXPRESS language. This model describes approximately 750 classes. There are three types of IFC classes: object classes, relationship classes and resource classes. The object classes consist in a triplet (GUID, OS, FU), where GUID (Globally Unique IDentifier) defines a unique identifier for the IFC object. OS (OwnerShip) defines the ownership features of this object, and FU (Functional Units) are the functional units. The latter define the context of use of the classes (i.e. the geometrical representation, its localization, its composition, etc.). The resource classes define a set of attributes used for the description of the functional units. These resources are organized as a hierarchical graph. The relationship classes represent the various relations (capacity, aggregation, etc.) between the object classes and the functional units. Today, the IFC standard is imposed in all tenders for civil engineering projects in many countries (USA, Norway, etc.). So far, this model is unsuitable for defining objects outside of the building context.

The IFG project (IFC for GIS), from IAI, aims at modeling geo-referenced objects outside the building context. The last version of this standard, IFC4, includes these features that extended IFC classes to allow IFC models to be positioned relatively to other geographic features. For doing so, one must firstly define the integration of BIM within GIS. In the next version, it will be possible to define geographical elements (such as IfcGeographicElement and IfcGeographicElementType) in order to increase interoperability between BIM and GIS. However, even if the IFG initiative is highly interesting, the goal is not to include GIS into the IFC. This approach aims at using the IFC as a medium of exchange for limited, but significant, information between GIS systems and AEC/FM (Architecture, Engineering & Construction).

In the field of geographic information, many standards have been proposed to address the problem of heterogeneity. Standards are a first way to solve the problems of heterogeneity encountered in the resolution of urban modeling. Several organizations,

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