Taxonomies of Building Objects towards Topographic and Thematic Geo-Ontologies

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Abstract. Spatial data infrastructures entail the integration of spatial data from various sources. Those data usually come with different semantics for same real world objects which impedes interoperability. Spatial data must be represented in a machine-understandable structure to tackle the heterogeneity problem. Ontologies provide explicit and semantically rich representation so that computers can understand the meaning of information. This paper presents preliminary works of an ongoing ontology alignment study for buildings in various geo-ontologies. In this context, different taxonomic classifications of some building object types that can be used in defining topographic and thematic geo-ontologies are given. In addition, some issues related to data integration in multi-resolution/representation spatial databases are briefly discussed within ontological framework.

Keywords: Taxonomy, Heterogeneity, Ontology, Geographic Objects

1. Introduction

Geospatial semantic integration provides a global view of diverse terms in different data sources. For example, a geospatial object is described as a river in one data source and a water body in another source; geospatial semantic integration reveals that the two terms fundamentally mean the same thing in the real world and merge them into a single term such as water body (Zhou 2008).

The new generation of information systems needs to handle semantic heterogeneity in making use of the amount of information available with the arrival of the internet and distributed computing. The support and use of multiple ontologies should be a basic feature of modern information systems if they are to support semantics in the integration of information. Ontologies can capture the semantics of information, can also be represented in a formal language, and can be used to store the related metadata, thus enabling a semantic approach to information integration. Sophisticated structures, such as ontologies, are good candidates for abstracting and modelling geographic information with the final objective of information integration (Fonseca 2008).

The aim of this study is to present different taxonomies of geographic objects in the example of buildings from various perspectives that will be useful for developing geo-ontologies.

2. Geographic Data Modelling from Multiple Perspectives

2.1. Topographic and Thematic Data Modelling

Topographic and thematic maps are two main types of maps in classical cartographic literature. In modelling geographic data, a same kind of logic can be used for reflecting different perspectives that various spatial applications require. Topographic datasets provides general-purpose data as a spatial reference for specific applications. Hence thematic datasets are dependent on topographic data. In this context, a geographic (geo-) database can be classified as two types depending on the point of view (PoV): 1. topographic geo-database, which consists of natural and artificial real world objects as well as elevation information, 2. thematic geo-database, which provides spatial distribution and structure of a specific subject about human and/or nature with qualitative and/or quantitative properties. For example, tourism, city, transportation, environment, demography and so on. Level of detail (LoD) is another important concept in defining semantic and geometric characteristics of real world phenomena in geographic databases. Resolution is common term that is used for denoting LoDs of geographic data. It can be either semantic or geometric (Basaraner 2012). As a result, different geographic databases with varying content for same geographic space can be built depending on purpose.

2.2. Taxonomies and Ontologies for Geographic Objects

People abstract phenomena of reality from different perspectives and at different levels of detail depending on how accurate a description is required. Consequently, concepts in ontologies may be depicted from a more general and global purpose to a very specialized context or a specific application. Typically, three levels of ontology are considered (*Figure 1*): *global ontology*, which contains reusable generic terms in different domains; *domain ontology* which contains terms that are specific in a particular domain (e.g. soils or geology) and *application ontology*, which contains all necessary terms to model a particular application. Each level is characterized by a specific granularity at which phenomena are abstracted and depicted (Broduer 2012, Fonseca & Llano 2011).

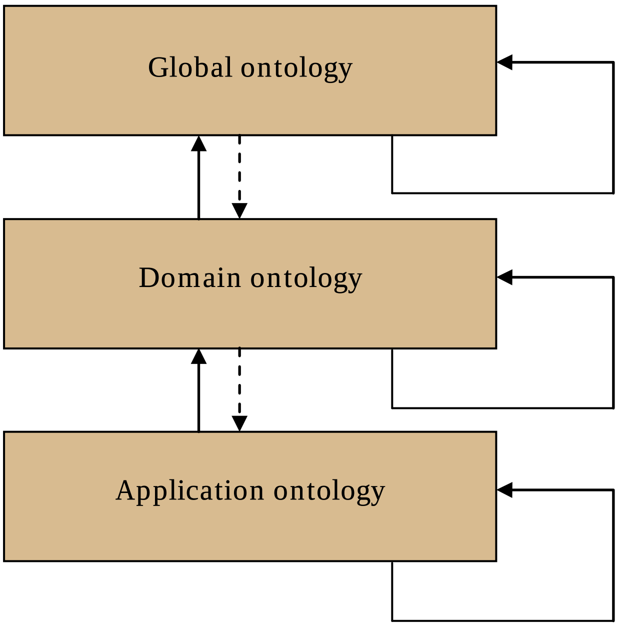

Figure 1 Levels of ontology (Redrawn from Broduer 2012).

A domain ontology specifies terms used to describe concepts in the domain and gives relationships between these terms. For example, a hydrology ontology contains concepts and terms such as lake, river, and creek. These become classes in the ontology and may themselves be sub-classes of a more general term, such as water body, and/or have their own sub-classes. Terms are often arranged hierarchically as a tree, forming a taxonomy, which is a very simple ontology. However, ontologies are typically more complex and are modelled as graphs (Wiegand 2010).

A common stage in the development of an ontology is the design of a taxonomy. Taxonomies, or classification systems, infer relations behind their formation based on context. The objective of the taxonomy was to form a hierarchical classification system that enables ontologies to express multiple spatial (semantic, geometric and structural) relations of geographic objects (Varanka 2009).

3. Experimental Study

Spatial data definitions vary depending on the point of view (PoV), the level of detail (LoD) and the purpose of use (PoU) (Basaraner 2012). Therefore, various maps, geo-databases, geographic data and map specifications are examined to constitute taxonomies or simple ontologies.

Semantic differences for same real world object in multiple geographic databases arise from the variety of PoVs, i.e. topographic and thematic and LoDs, i.e. resolutions/scales. In this context, topographic and thematic/city objects are dealt with as examples (*Figure 2*) and taxonomies of some building object types are investigated depending on the PoVs and the LoDs.

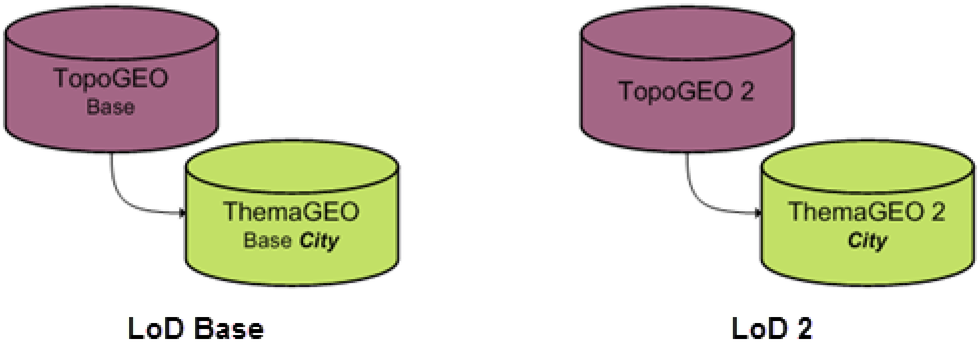

Figure 2 Multiple geographic databases designed in accordance with the LoDs (i.e. base level and 2nd level) and the PoVs (i.e. topographic and thematic/city).

Educational institutions/buildings/facilities are used as primary example. In this context, topographic object types and thematic/city object types at base level corresponding to high resolution or large scale (1:10 000 and larger) and 2nd level corresponding to medium resolution or scale (approx. 1:25 000 – 1:100 000) are hierarchically classified respectively (*Figure 3, Figure 4, Figure 5 & Figure 6*).

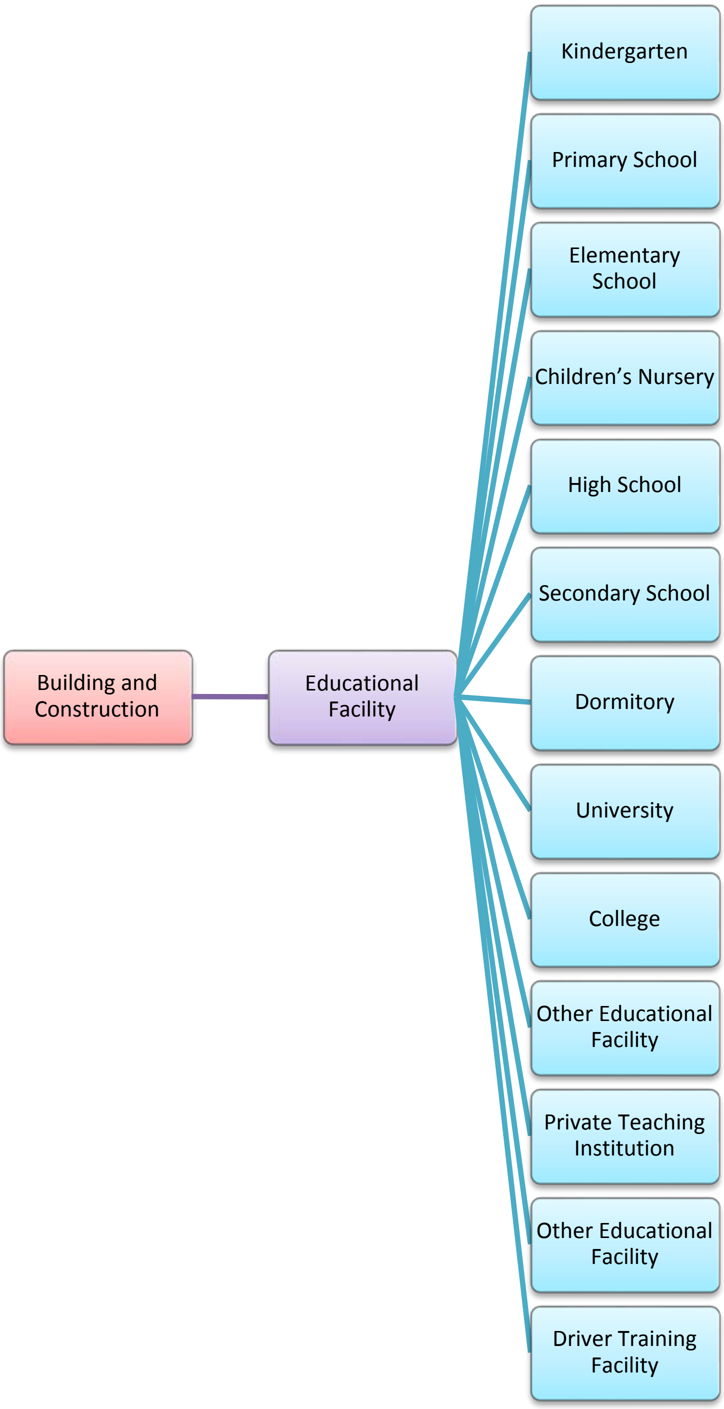

Figure 3. A sample taxonomy of *TopoGEO Base*.

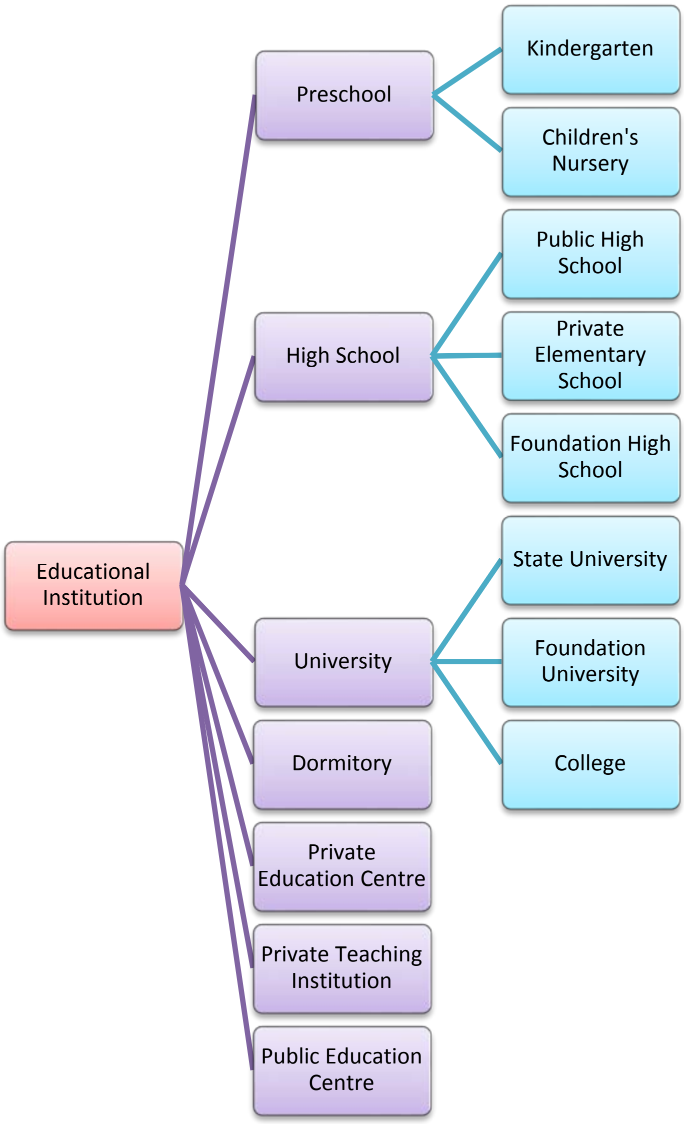

Figure 4. A sample taxonomy of *ThematicGEO Base/City*.

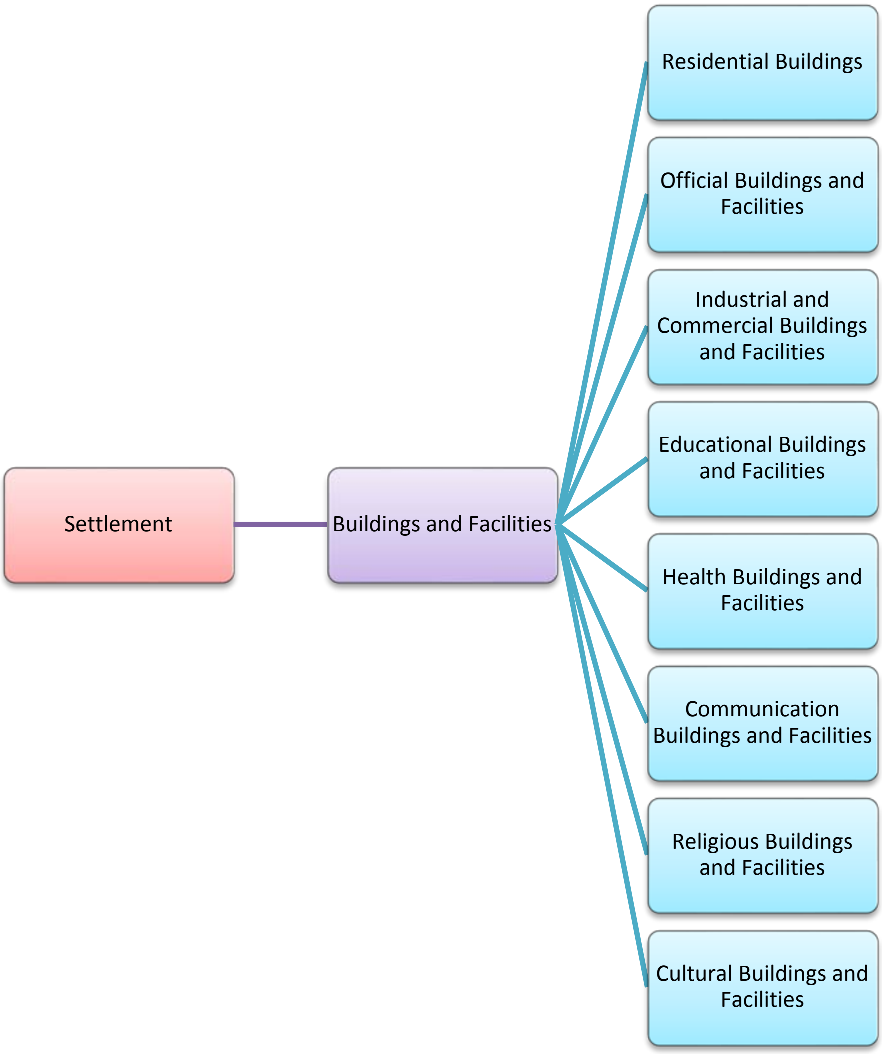

Figure 5. A sample taxonomy of *TopoGEO 2*.

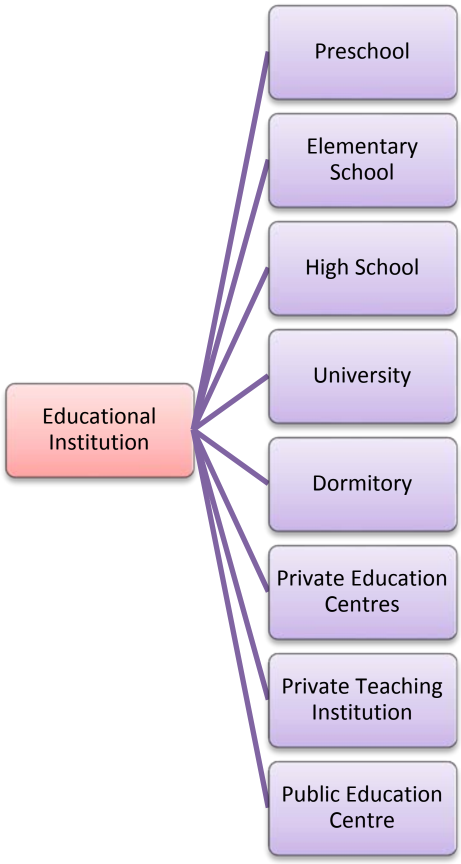

Figure 6. A sample taxonomy of *ThematicGEO Base/City*.

4. Results and Discussion

Multiple taxonomies can be created in order to describe same geographic objects with regard to application requirements and purpose. Taxonomies can be starting point for developing ontologies. On the other hand, ontologies also require modelling of non-taxonomic relationships. Geo-ontology alignment is another important issue that enables semantic integration of diverse geo-databases.

If it is examined how a *state university* is represented in different taxonomies or simple ontologies belonging to heterogeneous geographic databases, it can be seen that different semantics are usually assigned to this object type. It is taxonomically represented as *Building and Construction* >

Educational Facility > State University in TopoGEO Base, *Educational Institution > University > State University* in ThemaGEO Base/City, *Settlement > Buildings and Facilities > Educational Buildings and Facilities* in TopoGEO 2 and *Educational Institution > University* in ThemaGEO 2/City.

Development of multi-resolution spatial databases can benefit from ontological modelling since it should be dealt with the integration of spatial data defined from multiple perspectives. In addition to semantic integration, geometric integration in the instance level should be considered for spatial data.

5. Conclusion

Most of the current geo-ontologies have in fact taxonomic nature. So taxonomies can be the starting point for developing geo-ontologies with more sophisticated relationships. Integration of topographic and thematic objects is a common practice in cartography and GIS where the former is used as a spatial reference to the latter. In this paper, it is briefly presented the concept of heterogeneity from geographic perspective regarding the LoDs and the PoVs and sample taxonomies are given in this context. Future work will be to find correspondences between object types after creating ontologies.

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