4CitySemantics

GIS-Semantic Tool for Urban Intervention Areas

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Introduction

We present 4CitySemantics, a computational tool for City Planning. The main objective of this tool is to assist the participants of the urban development process in constructing adequate interpretations of a defined intervention site and its surrounding area (buffer), thereby contributing for better planning. The function of 4CitySemantics is to identify and classify both geographically and semantically the urban areas subjected to the intervention, which can be visualized. The key principle behind the tool is to offer the user as much flexibility as possible, so that s/he can develop customized semantic interpretations of the intervention areas in order to formulate an adequate intervention program. Such flexibility is achieved through the ample use of customizable ontologies for interpreting population and land use data, separating urban knowledge from the application tool, which can easily adapt to different urban semantic standards. By using the functionalities of the tool backed by the customizable ontologies, the urban planner can define a workflow to identify on a map a set of geo-referenced parcels belonging to the intervention areas and annotate them with semantic data regarding the use of the land. He can also annotate the intervention area with information regarding the type and size of its population. 4CitySemantics can also import data already semantically annotated, and that is ready for visualization.

Over the past few years, we have assisted to the development of the next generation Internet. The Semantic Web [1] is an extension of the current web, and while preserving the web characteristics, namely, it is open and decentralized, it offers new technology to make data on the web machine-interpretable, based on a powerful mechanism: inference. Knowledge in the semantic web is represented by ontologies, which are semantic formal models describing the relevant concepts, the relationships between concepts, and the constraints among them. The inference mechanism and the distributed and open characteristics are arguments enough to motivate and justify the use of urban ontologies for the Semantic Web. They can be shared, reused and extended fostering the interoperability between distributed urban knowledge and different applications.

The ontology driven tool

The use of ontologies has been a hot topic in urban planning computational tools [2], mostly for urban planning knowledge externalization, sharing, integration, and reuse. In 4CitySemantics, knowledge regarding land use classification taxonomy, land use identification and visualization workflow, parcels and areas data, and population characteristics, are represented using the standard W3C Web Ontology Language (OWL 2.0) [3]. 4CitySemantics separates knowledge from its application and so it is fully independent of any Land Use Classification Standard as soon as it is represented as an OWL ontology. Currently, there is just one classification system adapted for use in the application: LBCS [4], but any other land use classification standard can be added and used as soon as the respective OWL ontology is available and integrated. It was given relevance to the extensibility and modification of the ontologies, so it should be easy to adapt other land use systems. Thus, at present, we have an OWL 2.0 ontology for the LBCS land use standard [5], backed by one ontology that serves as a skeleton for any land use system; an ontology representing a land use identification workflow for LBCS, also backed by an ontology intended for representing any land use workflow; and finally, an ontology for the population data, which can be customized to fit the available population indicators. The articulation of the ontologies is showed in Figure 1.

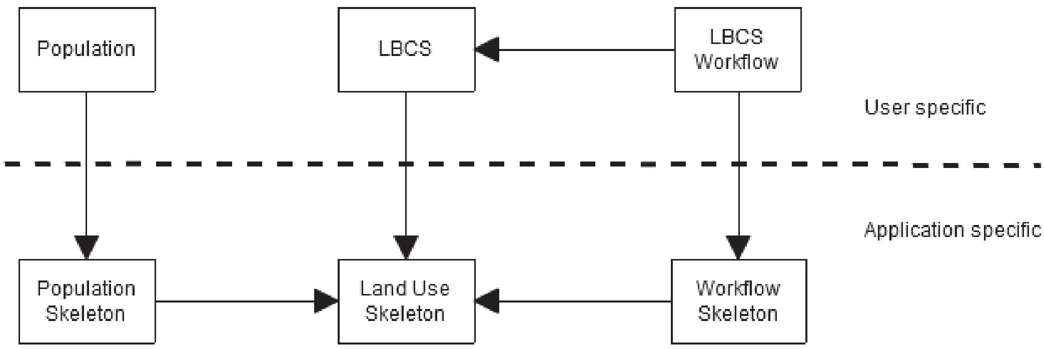

Figure 1: The ontology modularity that allows the tool to use any land use system, workflow and population indicators. The tool only relies on the concepts of the application-specific ontologies.

With 4CitySemantics users are able to 1) choose the intervention area and define the buffer area on a map; 2) define any other areas on the map as necessary; 3) classify the parcels on the selected areas in accordance with some land use classification standard represented as an OWL 2.0 ontology; 4) follow an identification land use process that can be customized using the provided ontology; and finally 5) associate and graphically visualize semantic data related to the type of population living in those areas, using the population indicators defined within a population ontology, which can also be customized.

Buffer and Intervention Area Definition

Typically, the first task the user must perform is to define the intervention and the buffer areas. In 4CitySemantics, the user can access a map built from geospatial vector data and identify the parcels that compose these areas, as well as, other areas that can be created as needed. All the information is stored in an ontology representing the current project. In figure 2, we show the 4CitySemantics interface: the user is selecting the features belonging to the intervention area, which is highlighted.

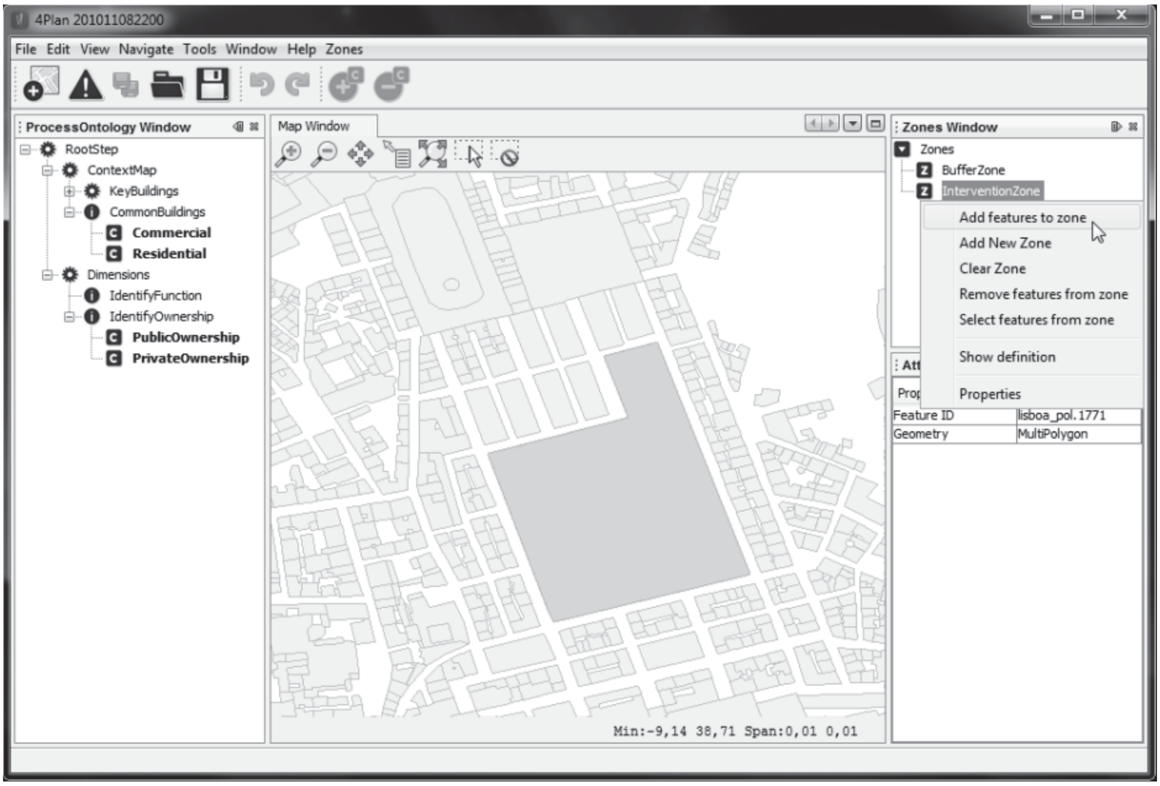

Figure 2: Identification of the intervention zone

Land Use identification and visualization workflow

If there is a Land Use OWL 2.0 ontology, parcels can be annotated with land use information that corresponds to concepts of that ontology. The user can also define a workflow for the identification and visualization of land use semantics. The land use categories are loaded from the land use ontology, and the workflow ontology defines, with OWL semantics, the assertions that should be made when classifying the map parcels and the queries corresponding to each workflow step. These queries will be used to show on the map the parcels that fit the specified criteria, which can be any combination of OWL expressions. The parcels are also colored on the map according to the color of the land use category and depending on the selected workflow step as clarified in following.

We can see an example of such workflow on the left of Figure 3. In this example, the workflow is composed of two main steps: Context Map and Dimensions. The Context Map is an identification step composed of 2 sub-steps: KeyBuildings and CommonBuildings. This means that at this workflow step (ContextMap), we may identify Hospitals, Police and Schools (bold) and also Commercial and Residential

buildings. Each of these steps is associated with a combination of land use concepts. Note that LBCS is a hierarchical classification system and even if we associate a certain workflow step with a LBCS concept we can explore further down on the hierarchy.
All the classifications made are stored in an OWL ontology that can be read by other applications, facilitating communication and interoperability.

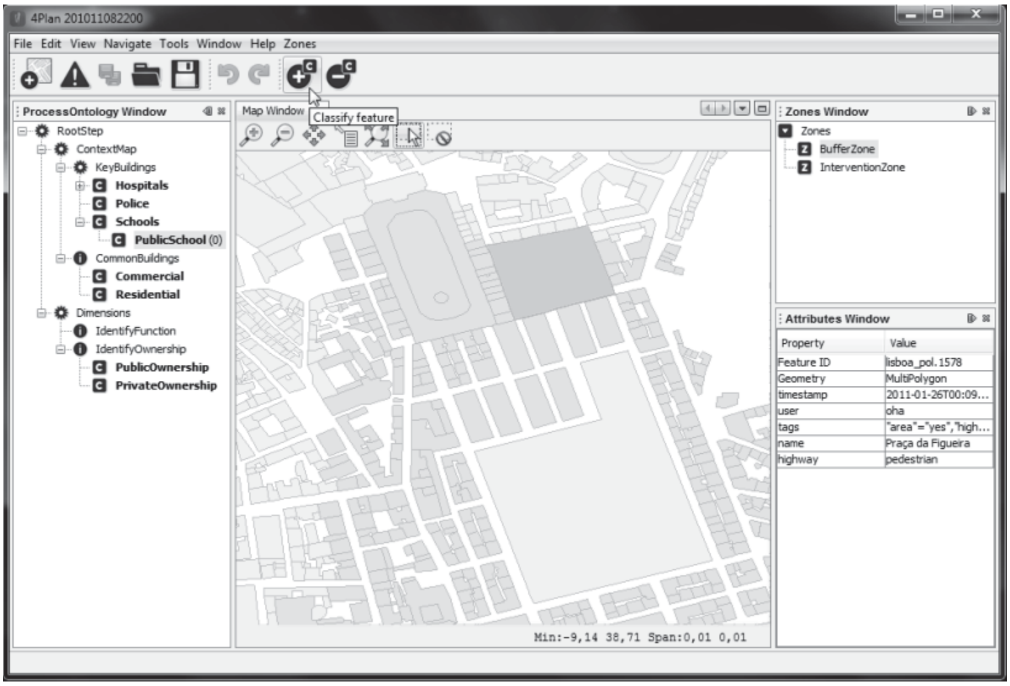

Figure 3: Classifying a feature with the category “Public School”

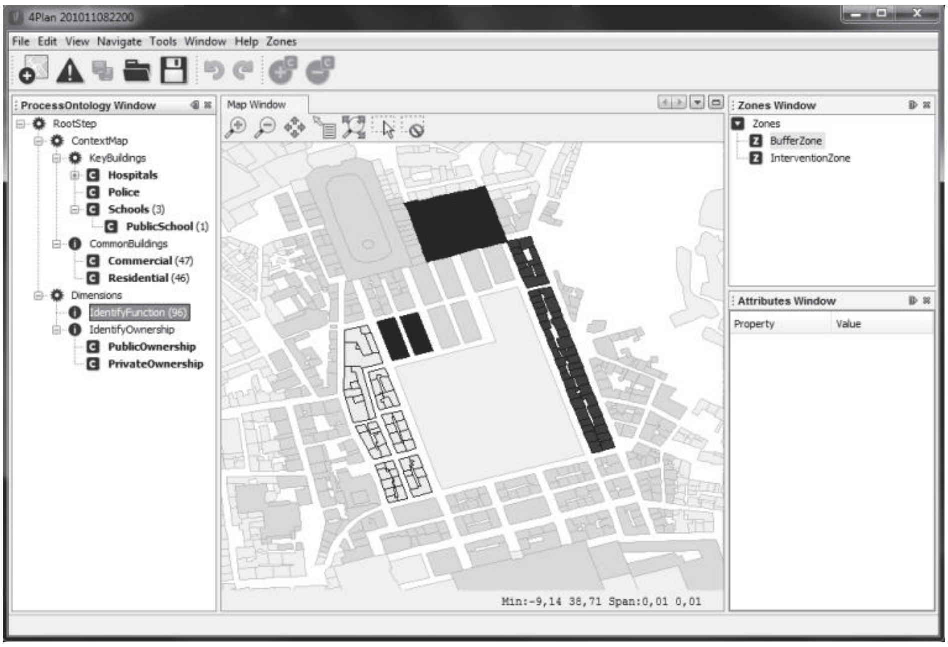

Figure 4: The selected workflow step shows all the parcels according to its category from the Function dimension of LBCS.

Population Semantics

It is relevant to the planning process to know about the population size and type, in both intervention and buffer areas, and in any other major zones. Besides size, it is useful to know age distribution, level of income, and education levels, among other information. We have developed a population ontology that is easily extended to include any population indicators. We consider two main types of indicators: simple indicators (ex: fertility rate or total population number), and distribution indicators (ex: the age or income distribution of the population). The application automatically loads these indicators from the ontology and provides the user with the adequate means to edit both types of indicators. It also displays charts to visualize the asserted information.

In Figure 5 we see the process of semantic annotation of the buffer area with population information. In addition, the user is able to annotate with population information any defined area: the intervention, the buffer, or any other one.

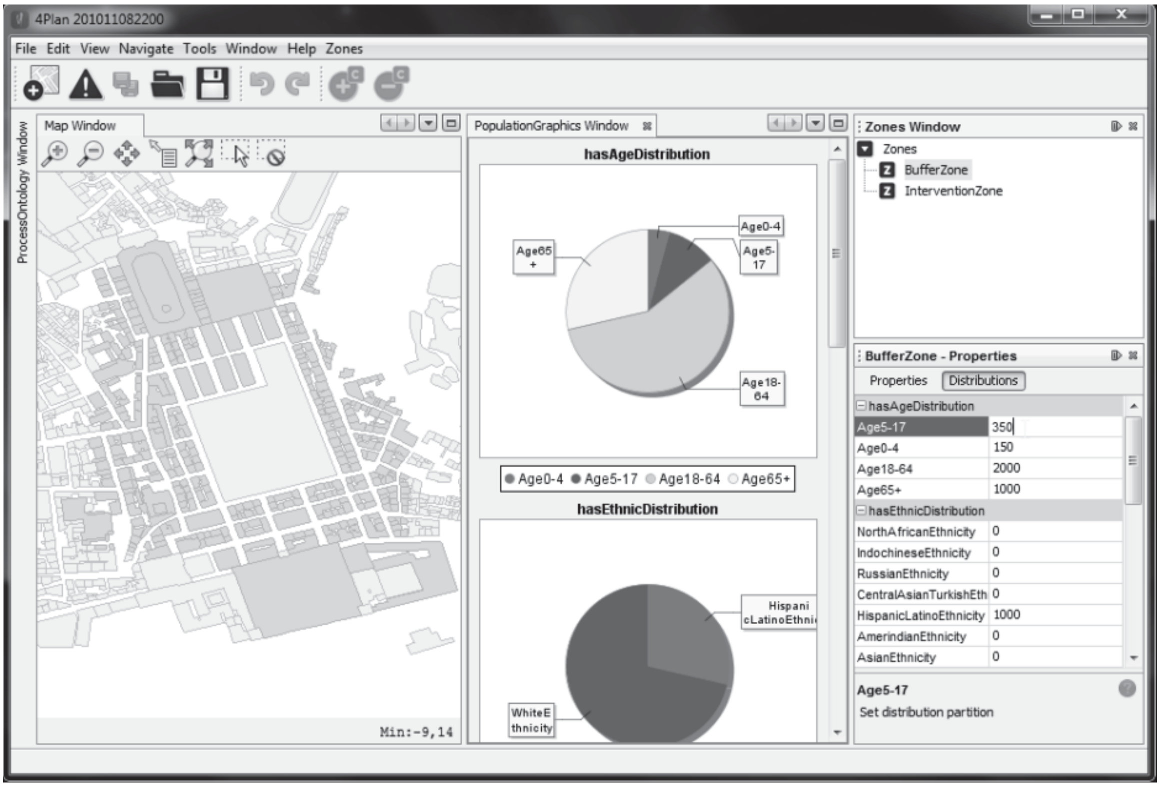

Figure 5: Defining the population data for the Buffer area.

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References

[1] **Berners–Lee T., Hendler J., and Lassila O.** (2001) The semantic web", Scientific American May 2001. Available online: http://www.sciam.com.

[2] **Teller J, Billen R, Cutting-Decelle A-F.** (2011) Editorial – Bringing Urban Ontologies into Practice, ITcon Vol. 15, Special Issue Bringing urban ontologies into practice, pp. 108-110, http://www.itcon.org/2010/7

[3] (2011) OWL 2 Web Ontology Language Document Overview. http://www.w3.org/TR/owl2-overview/. [Acessed: 10-Jan-2011].

[4] **American Planning Association** (1999). Land Based Classification System. [Online]. Available: http://www.planning.org/lbcs/. [Accessed: 06-Feb-2011]

[5] **Montenegro, N., Gomes, J., Urbano, P., Duarte, J.** (2011) An OWL2 Land Use Ontology: LBCS. Accepted for publication in Cities, Technologies and Planning" (CTP 11) in conjunction with the 2011 International Conference on Computational Science and its Applications (ICCSA 2011)