Ontologies for an Improved Communication in Urban Development Projects

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1 Introduction

The main objective of the COST Transport and Urban Development Action C21 is to increase the knowledge and promote the use of ontologies in the domain of urban development, in the view of facilitating the communications between information systems, stakeholders and urban specialists at a European level.

Secondary objectives of the Action are:

- producing a taxonomy of ontologies in the urban development field, contrasting existing design methodologies, techniques and production standards;
- developing an urban development ontology both in textual and visual (graph) presentation and a visual editor to integrate and update concepts, definition, photos into the ontology (software tool);
- developing a set of guidelines for the construction of urban development ontologies, based on practical examples (cases);
- analysing the role of ontologies in the daily practice of urban development.

The research work has been organized along three working groups, the first one dealing more specifically with methodologies for developing urban development ontologies, the second one dedicated to ontological issues raised by cross-comparisons between European urban development cases and the third one dedicated to practical applications of ontologies in the urban development field.

It was soon acknowledged by the COST C21 members that there is no straightforward way to define end-users' needs in terms of urban ontologies at the moment. Technology-driven approaches are not relevant as they would rapidly lead to restrict the research to the sole issue of computer representations while the ambitions of this Action extend far beyond this aspect. Furthermore conceptualizations are often tacit or implicit in the urban development domain and efforts to formalize these conceptualizations are generally viewed as "over-simplifications" by experts that are struggling to defend their scientific and technical legitimacy.

It was hence suggested to adopt a "prospective approach" in order to better identify the potential role of ontologies in fostering the exchange and support of urban knowledge. In a design-like perspective, the identification of "end-user needs" and relevant issues that could be addressed by ontologies in the urban domain should hence be considered as a product rather than a starting point of this Action. The main

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premises of such a prospective approach are briefly summarized in the next section, while the third section will address significant issues emerging from the work of the Action and relevant experiences in the domain of urban ontologies.

2 Prospect for Ontologies in the Urban Development Domain

Ontologies once defined as the theory of objects and their relations has certainly become a central issue in any scientific discipline, from philosophy to chemistry or social sciences. In the context of this Action, we adopted Guarino's definition of ontologies emanating from information sciences.

Guarino [1] defines an ontology as "an engineering artifact, constituted by a specific vocabulary used to describe a certain reality, plus a set of explicit assumptions regarding the intended meaning of the vocabulary words." Such ontologies are usually designed to be enshrined in computer programs. They determine what can be represented and what can be said about a given domain through the use of information techniques. Accordingly "ontology designers have to make conscious and explicit choices of what they admit as referents in a particular system or language." [2] The way to make these choices is an important subject of research given their practical implications over the long-term.

Generally speaking, the main applications of ontologies in information sciences are, on the one hand, knowledge sharing and reuse [3] and, on the other hand, the integration of data and system interoperability defined as "the ability of two or more systems or components to exchange information and to use the information that has been exchanged." [4]

In the urban development domain, both these objectives are directly relevant. Knowledge sharing and reuse is a critical issue in the view of building a common culture between experts, stakeholders and decision-makers. Interoperability between different Urban Information Systems raises issues of communication between different urban domains (cadastre, population, planning, environment etc.), scales (nation, city, district), purposes and qualities of data (2D/2.5D/3D, topologically correct/incorrect, precision).

Ontologies have also an important role to play in revealing the logical structure of existing conceptualizations. "Conceptualizations are often tacit. They are often not thematized in any systematic way. But tools can be developed to specify and to clarify the concepts involved and to establish their logical structure, and thus to render explicit the underlying taxonomy." [5] This third application may be considered as a "by-product" by specialists in ontologies. Still it appears extremely relevant in the context of this Action as urban systems have been characterized by very fast evolutions over the last decades. It is generally agreed that addressing these evolutions requires to adapt the way urban development is conceptualized. At the same time, efforts to describe the transformation of our urban systems forged a series of new concepts and neologisms (urban sprawl, emerging city, intermediate territory etc.) which partly overlap without fully covering the same reality. The relevancy of emerging conceptualizations is frequently questioned and there remains significant disagreement on the definition of key concepts commonly handled in the discipline.

3 Relevant Experiences in the Urban Development Domain

Some experiences directly relevant for the formalization of urban conceptualizations are briefly summarized in Figure 1. Even though none of these can be regarded as "plain ontologies", they inform us about difficulties inherent to our project.

	Construction sector classification	AEC Modelling	GIS Ontologies	Urban knowledge bases
Examples	ISO 12006 - 2 ISO 12006 - 3 ISO 18629 - Process Specification Language	IFC/IFG - Industry Foundation Classes	Open GIS initiative GML 3.0	EUKN - European Urban Knowledge Network COST C20 URBANET, HEREIN
Main Purpose	Standardisation Entire life cycle	Software Interoperability	Domain Interoperability	Exchange of experience Cataloguing
Leadership	Normalisation bodies	Internation Alliance for Interoperability: AEC & software industry, Public bodies	Research organisations Private agencies	European Networks Public/Private bodies
Scale	Focused on building entities (buildings, bridges) and construction complexes (motorways)	Buildings and Sites	Street networks to satellite img processing	From public spaces to urban regions
Formalism	EXPRESS bcXML taxonomy	EXPRESS ifcXML	XML, GML, OWL	Taxonomy ISO 5964 (multilingual thesauri)

Fig. 1. Relevant experiences identified in the urban development domain. These experiences are ordered from the most formalized ones *(on the left)* to the less formalized *(on the right)*

Arguably, the most formalized conceptualizations are issued from the construction sector in a view of standardization. Urban classifications tend to be less formalized but broader in their scope (ranging from heritage conservation to safety in public spaces). Further differences can be observed in the purpose of these conceptualizations, as ISO-12003 are designed for the classification of building components while Industry Foundation Classes (IFC) have been developed to allow a greater interoperability between computer models of building products.

3.1 Ontologies as a support for an improved communication

Interest in ontologies in the urban development field partly derives from the fact that communication, negotiation and argumentation are increasingly considered as essential to sound urban decision-making. Urban planning indeed evolved from pure "rationalistic models" to more transactional ones [6]. "Strategic planning", multi-stakeholder partnerships and public participation have now become mottos in the domain. Although sometimes vague in their nature and scope, the success of these notions reflects the importance of communication in present urban planning processes.

Still it has to be stressed that the so-called "communicative planning" relies on the basic assumption that stakeholders share some common understanding of terms, concepts and valid inferences, while many urban conflicts appear to be precisely fuelled by discrepancies between such basic definitions [7], [8]. Ontologies could hence be viewed as a way to address divergences between conceptual models, may it be to make these divergences more explicit and traceable.

3.1.1 Encompassing multi-stakeholder views

This was somehow the option adopted by the ISO 12006-2 standard [9] which was developed to coordinate national classifications of building products and components. The classification is intended to cover the entire life-cycle of the building from its preliminary design to its maintenance. This standard is the result of a longstanding effort of the construction sector as it was initiated in the 1950s with SfB — the first Swedish classification scheme.

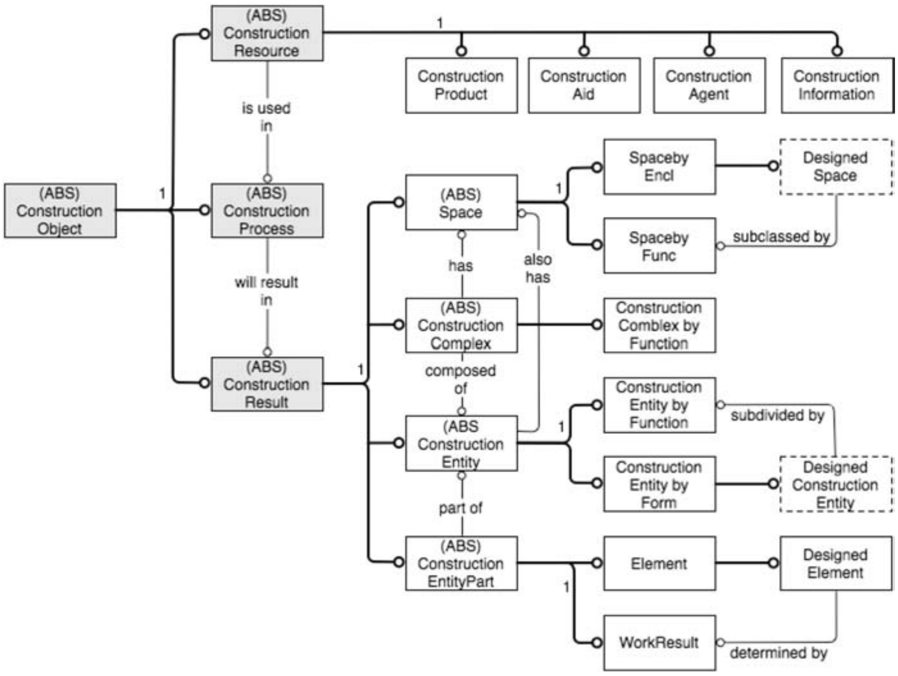

Fig. 2. The ISO 12006-2 model for classification of construction products and components, after Ekholm [10]

Quite interestingly, the ISO 12006-2 has been explicitly designed to encompass diverging views of building components. It is indeed based on three types of basic objects: construction resources, processes and results (Figure 2). The model makes a clear distinction between work results — walls or roofs for instance — and resources like products that are mobilized in the construction process — beams, bricks etc. From a conceptual point of view, a similar distinction may be established in the urban domain between mere resources (like transport systems, infrastructures) and products (such as mobility, public spaces and the like).

Construction results include construction complexes (airports, large combined buildings) and construction entities (single buildings or infrastructures) along with spaces and construction entity parts (walls, floors etc.). Most interestingly the ISO 12006-2 model defines two alternative ways to define spaces, either by their enclosure (inner space, semi-opened etc.) or their function (kitchen, living, hall etc.). A similar approach has been adopted for construction entities, as these can either be defined by their main construction method (girder bridge, arch bridge, or truss bridge) or their function-or-user activity (railroad bridge, motor vehicle bridge or pedestrian bridge). Obviously such dual views of the reality are directly relevant in the urban domain.

Even though initially designed for classification purposes, it would be tempting to use such standards in order to formalize communication between actors and thereby reduce possible misunderstandings. Still, as suggested by John Lee and Dermott McMeel in their contribution to this book, this would be oblivious of the fact that some degree of ambiguity, redundancy and even inconsistency should be admitted in communication between human actors in order to keep some adaptability to the situations at hand, to allow innovative solutions to take place (even though in an unpredicted way) and, basically, "to make urban systems work". Sociology of action informs us of the fact that any production process can be interpreted as a chain of "translations" from initial design sketches to their progressive specification through plans, product specifications, terms of reference and final assembly. Any translation between these different steps involves a redefinition of the final object's properties, as each of them is somehow characterized by its own "ontology": it is now a trivial statement that a designer will not necessarily have the same ontology of buildings as a technical engineer or a construction company… The transformation of the final object through all these different translations can be formalized as a form of mapping between ontologies. This research avenue is certainly more promising than the one consisting in trying to format all communications between actors through a single ontology.

3.1.2 Support for Public Participation

Besides the above-mentioned diversity of expertise fields, public participation has now become a key communication issue in the urban development sector. Quite significantly it is now backed by significant legally-binding international agreements, as for instance the Aarhus convention, which recognizes a right of access to information and public participation in environmental matters [11]. Such conventions are applicable to the urban domain as "man-made environments" typically fall under their scope [12]. It basically means that technical information has to be made accessible to a wider audience, which may require an adaptation of interfaces and visualization tools to different user profiles and centers of interest. In this book, Claudine Métral, Gilles Falquet and Mathieu Vonlanthen suggest the use of an interface ontology in order to support a diversity of viewpoints on the same information. More significantly, the "participation revolution" implied that the general public is now increasingly viewed as a valuable provider of local urban knowledge and expertise. These authors hence propose the adoption of an ontology-based model in order to integrate and connect in the same knowledge base information coming from heterogeneous sources (Geographical Information Systems, natural language texts, personal interviews, pictures etc.), which is certainly a key challenge of present urban communication systems.

Clearly then, communication between stakeholders appears as an important application of ontologies in the urban development domain, especially when divergence about the meaning of concepts and their relations is regarded as a source of information rather than some form of pathology.

3.2 Issues of scale and versatility

One of the greatest ironies of information technology is that once conceptual structures are represented in software systems they become remarkably difficult to change, despite the inherent volatility of electronic media. In part this is because software systems are complex and require sophisticated skills and expensive resources to maintain them.

Coping with the evolution of techniques has been one of the main challenges faced by Industry Foundation Classes (IFC) since their first release in 1995. IFC classes are designed to support interoperability between building models [13]. They are now widely accepted by the industry and major Computer Aided Design software systems support IFC classes for file based exchanges with planning tools, cost evaluation applications etc.

By contrast with ISO-12006, IFC have been designed along an ad-hoc approach, without referring to an explicit model or ontology. Hence it is not clear whether the selection of building components is complete and if the classes are mutually exclusive [10]. The schema is object-oriented and proposes a deep hierarchical sub-division of building elements. Objects supported by IFC include products, processes, controls, resources, actors, groups and projects. The model was initially formalized in EXPRESS, but an XML version of IFC classes has been proposed recently. Quite interestingly IFC classes include the notion of site, which is not supported by ISO-12006-2. An IFC extension for GIS (IFG) has been developed in order to promote interoperability between Computer Aided Design software, Geographical Information Systems and urban applications like permitting systems.

A series of technical committees have been organized to support and feed extensions of IFC. One of these committees directly associates IFC designers with software companies in order to validate proposed extensions. Paradoxically such an organization further constrains possible reorganizations of the entire model, with a view to improving its overall consistency. In a somehow different approach from the one adopted by the IFC consortium, Anne-Françoise Cutting Decelle discusses the applicability of Model Design Approach (MDA) to support an increased versatility of computer systems.

MDA is based on the now "usual" idea of separating the specification of the operation of a system from the details of the way the systems uses the capabilities of its platform. Its strength resides in the mapping between different layers of computer models, from the most conceptual to platform specific, and from one version to another of the models at either of these layers. Ontologies are used to support the mapping, either for specification, abstraction or reusability and enhancement purposes. As stated by Anne-Françoise Cutting Decelle, MDA has been mostly applied in large business companies for interoperability between Enterprise Resource Planning (ERP) applications until now. It is a promising alternative to standardization approaches, in those domains like urban development where it is difficult to agree on common ontologies shared by different information systems.

3.3 Design, engineering and validation of ontologies

One of the aims of the COST C21 Action is to propose guidelines for the development of urban ontologies. A preliminary account of the state-of-the-art in the domain has been established by Roussey [14]. She distinguishes different types of ontologies according to their purpose, expressiveness and specificity. Different tools and methods to design ontologies are presented and discussed. The development process of an ontology is subdivided into six main steps: ontology specification, knowledge acquisition, conceptualization, formalization, evaluation and documentation.

Applying such general guidelines to the specific domain of urban development has been the subject of different papers gathered into this book. The proposed approaches may differ along with the method for detecting concepts, for identifying relations between these concepts and for building a taxonomy of terms.

3.3.1 Bottom-up approaches

In this book, Berdier and Roussey compare different approaches to building urban development ontologies. The first method consists in extracting concepts from technical dictionaries in the domain of road systems. The second method is based on interviews among several experts from different fields of expertise in the view of developing an urban mobility ontology. These two methods can be understood as bottom-up approaches as they are starting from the most specific concepts and tend to generalize them. Such approaches provide very specific ontologies with fine grain detailed concepts [14]. Still they may lead to problems of consistency and coherency of the ontology. Quite interestingly such bottom-up approaches may also help to reveal divergences about concept definitions and their relations, but may result in ontologies that become overtly “user-specific” with little if any possibility to be adopted by various experts/systems.

Another approach consists in extracting knowledge directly from existing databases in order to derive ontologies either through an automated process as suggested by Nogueras or through a generalization of their conceptual schema as proposed by Chaidron in this book. Nogueras applies *Formal Concept Analysis* techniques for the automatic creation of a formal urban network ontology that integrates the mappings among different road taxonomies. This allowed the integration of three local road network databases and their interoperability (SIGLA, TVIAN and AYTO). Chaidron describes the method adopted for the reengineering of Brussels’ URBIS spatial databases. In a first step, the conceptualization lying behind the information system was formalized. This required a return to initial documentation and to proceed to interviews with the database managers. In a second step the authors compared the definition of concepts with the topological matrix of the

ER databases. This second step implied a further revision of some definitions in order to enlarge their scope as it helped to reveal inconsistencies in the initial ontology.

Combining these two approaches, automatic extraction of ontologies and topological matrix analysis appears as a promising avenue for deriving ontologies from urban databases in the view of their re-engineering. As urban information is more and more available in digital format, reengineering is becoming a major concern for most institutions in charge of the maintenance of these data. Data reengineering may indeed be required by the present evolution of techniques (migration from one platform to another, adoption of open-GIS format), of the requirements (new uses of the DBs, increased performance requirements, web access, inter-operability) or the data itself (integration of new information sources, 3D extensions, use of automatic acquisition techniques).

3.3.2 Top-down approaches

Two articles are addressing methods for developing top-level urban development ontologies. The benefits of top-level ontologies are that they are usually more consistent and are easy to adapt to new uses [14].

Trausan-Matu's socio-cultural ontology is based on Engeström Activity Theory and the categorization scheme of Peirce. The entire ontology is established on a basic triad that relates Subjects to Objects via mediators called Artifacts. This triad has been extended by Engeström in order to include Rules, Communities and Division of Labour. It is suggested by the author that these six top-level nodes and the relations that hold between them are capable of representing a number of diverse urban features. Actually the mere notion of Artifact, as a mediator between Subjects and Objects, but also between Rules and Communities or between Communities and Objects is certainly a stimulating one for those who are curious about the way urban objects are produced, operated and used by individuals or communities.

Finally Caglioni and Rabino propose to derive ontologies from an abstraction of urban models. After Forrester, and his seminal work *"Urban Dynamics"*, a number of models were indeed developed to better understand and predict the development of cities. Most models are addressing the relations between the development of urban economy, land use and mobility patterns (with since the 1990s a greater attention towards environmental and social issues). Caglioni and Rabino suggest that these urban models are unique sources for extracting domain ontologies as they typically include precise definition of concepts (through their inputs, outputs and main internal variables) and relations holding between these concepts (through their systems of equations). The author's demonstration is based on an ontology extraction from the Lowry model developed in the 1960s. By definition this model is based on a specific "worldview" and hence a certain domain ontology. Extracting ontologies from urban models hence appears as a way to decipher the evolution of those simplified "static models" to the complex dynamic models that are presently in use.

3.4 Ontologies for the characterization of Urban Processes

Current ontologies for information systems are mostly static, emphasizing objects with attributes and relationships over operations. They tend to minimize possible controversies about concepts, or ambiguities about their exact meaning. This may be because the roots of Geographical Information Systems are static, map-based models of the world and because of the emphasis in object-oriented approaches on attributes and relationships rather than on processes.

3.4.1 Evolution of the city's shape and limits

Quite typically, the evolution of a city's shape and its components over time are usually not encompassed in such static ontologies. This is the subject of two contributions.

The first one by Eduardo Camacho and François Golay is addressing morphological processes. The authors do not solely consider the transformation of the urban form but also the evolution of its conceptualization over time. It is generally admitted that some transformations of the urban form can not be interpreted without referring to a concomitant transformation of the way the city or some of its components were defined. Around the XVIIIth and XIXth century, the nature of the European city was largely altered as its military role literally collapsed. At the same time production activities grew very rapidly and they were more and more concentrated within urban nodes, while many cities were rather "exchange places" until then. This "ontological transformation" of the city was reflected in the urban morphology by a number of phenomena: the suppression of defence walls, the opening of large avenues for facilitating the movement of goods and people, and an unprecedented growth of the building stock to accommodate the incoming population.

It would be very difficult to interpret such morphological processes without referring to the evolution of the city's role and nature. All the more as it usually involves the "emergence" of some urban concepts. The suppression of defence walls for instance led to the creation of large "boulevards", an urban innovation that would soon be adopted in a number of urban extensions and transformations throughout Europe and that is still in use in present urban design.

Moreover, as a scientific discipline, urban morphology can be interpreted as an effort to relate the continuous development of the built environment with sporadic shifts in the way the city is conceived. The discipline actually developed in reaction against those who, in the first half of the XXth century, considered that European cities had to be almost entirely destroyed and built anew so as to cope with the demands of fast transportation systems and of the up-coming "automobile city". Research in urban morphology highlighted that, historically, radical transformations of the city's ontology never implied a total restructuring of pre-existing urban forms. On the contrary, some specific urban features like for instance medieval urban patterns or Royal places demonstrated a remarkable stability over time although the "urban systems" they formed part of had been changing radically.

In other words, the analysis of "morphological processes" should not be restricted to the evolution of the built environment but also encompass the evolution in the way a given urban feature may be conceptualized over time.

The second paper dealing with morphological processes addresses the way urban sprawl is conceptualized. Instead of using crisp delineations of urban boundaries, Hyowon Ban and Ola Alqvist suggest applying fuzzy set theory membership functions in order to discriminate between urban, exurban and rural areas. The authors argue that the definition of these areas is inherently vague and should be acknowledged as such in urban ontologies. Complimentarily the spatial implications of this vagueness can be evaluated and mapped. They demonstrate that fuzzy definitions of exurban areas are much closer to reality than crisp definitions. Still first-order logic ontology languages, like OWL for instance, do not support fuzzy memberships or fuzzy inferences at the moment. The authors suggest that these languages should hence be extended or revised in order to recognize the vagueness of some terms and to admit partial belonging to several categories. It is undoubtedly an important requirement at the time of making urban ontologies applicable to the field. Defining membership functions and measuring their spatial implications would constitute a significant step forward in the elicitation of urban conceptualisations.

3.4.2 Decision-making processes

This is all the more important as controversies about definitions can have important social, economical and political implications. Spatial processes such as sprawl or exurbanisation are intimately linked with individual and collective decision-making processes. Uncertainty not only relates to the interpretation of the 'State of the World', as exemplified by the above-mentioned case, it also applies to future decisions of individual and collective actors as well as to the likely impacts of given actions, all of which remain partly unpredictable in most cases. Plans and regulations are precisely designed to canalize anticipated investments, formalize collective intentions regarding urban development and, thereby, reduce uncertainties about the evolution of the urban system. They can hence be interpreted as a form of spatial coordination of the actions of diverse players (municipalities, urban services, private developers etc.), whose decisions are strongly interdependent. Quite paradoxically the decision-making dimension of planning is often ignored or left implicit in present spatial representations of urban development.

Lew Hopkins develops in this book a top-level ontology of urban decisions and plans. He distinguishes between two basic types of actions in terms of urban decision-making: investments and regulations. Both of which are closely intertwined and characterized by locational attributes. Decisions are defined as information about future actions. The effects of decisions are of a different nature than those of actions. He suggests to categorize urban decisions into three types: locations, alternatives and policies. Interestingly the ontology proposed by the author does not solely address the representation of 'robust' decisions and actions, but is intended to capture the net of conditional intentions from different actors that progressively shape the day-to-day urban decision-making. It certainly constitutes an important step forward in a better conceptualization of urban decision-making processes.

While the contribution of Eduardo Camacho and François Golay is addressing 'backward-looking' urban processes, the ontology proposed by Lew Hopkins is rather 'forward-looking' even though it may be used to document past decision-making processes. Urban ecology typically lies at the nexus of these two approaches as it aims to prospect local potentialities for urban development, considering the past and present states of the city, while avoiding narrow historical or geographical determinisms. As such it may be interpreted as a form of 'bridging' between both types of ontologies and certainly deserves further consideration in the view of conceptualizing urban development processes.

3.6 Language and institutional differences

The establishment of a multilingual ontology cannot correspond to the juxtaposition of N monolingual ontologies. It relies on the construction of a common conceptual taxonomy where all languages should have equal status. Still experience gained from previous attempts to build multi-lingual urban development glossaries informs us of the difficulties related to this enterprise. It should indeed be acknowledged that, besides language differences, urban development conceptualizations are typically affected by their institutional context. Local development plans are for instance recognized as a key planning instrument in most European countries, but their purpose, form, content and value may somehow differ from one country or region to another.

Spanish and Italian urban planning systems are very similar to each other due to their common legal and cultural heritage, though growing differences can be observed in the nature of core instruments that form the basis of urban development practice in these two countries. Identifying differences between similar concepts may be more interesting than insisting on their main commonalities, as it fuels a critical review of the reasons and values lying behind these divergences, as well as their costs and benefits in the broader meaning.

In the same vein, Vilches and Bernabé applied the Methondology procedure to the development of urban hydrology ontologies. Quite interestingly the preliminary identification of concepts was based on the European Water Framework directive along with various other sources and dictionaries (thesaurus of UNESCO, Thesaurus GEMET etc.). This European directive provides a unified conceptual framework that has been transposed in each Member State and the proposed ontology could hence be used for inter-administrative, cross-border collaboration between Spanish and French authorities.

Such collaborations are not solely increasingly required by daily urban management issues, they tend to generalize in the view of exchange of knowledge and good practices. The European Urban Knowledge Network (EUKN) precisely aims at capitalizing and disseminating urban knowledge amongst local authorities. An e-library has been built to gather documents regarding urban policy at large (http://www.eukn.org). Quite interestingly it can be seen from figure 3 that the thesaurus designed to structure the knowledge base is very wide in scope and ambition as it spans from land use to crime prevention and integration of social groups. Arguably these different concepts are related to different “scientific disciplines” which developed their own “ontologies”. Furthermore, although some documents have been translated into different languages, the taxonomy is solely available in English which is quite an important limitation given the expected audience of this library.

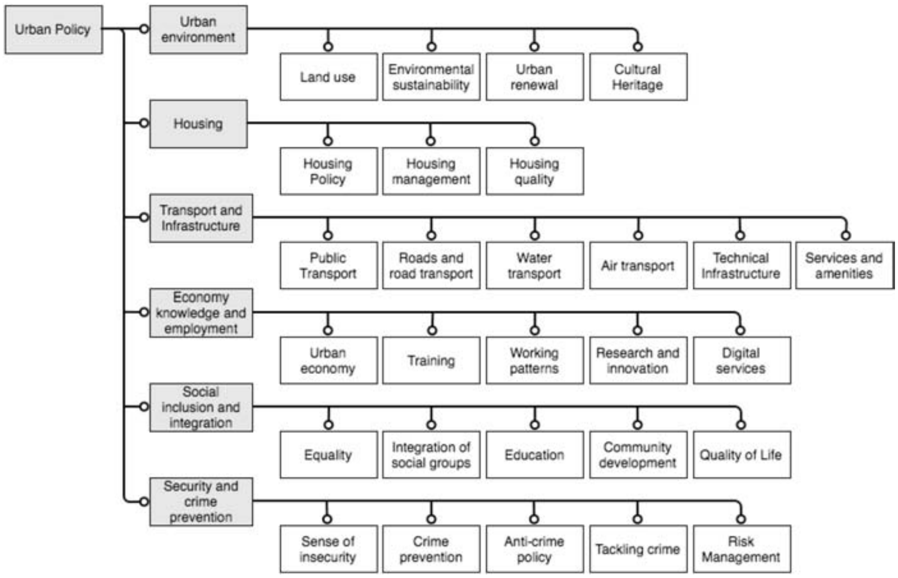

Fig. 3. The European Urban Knowledge Network (EUKN) top-level ontology. The thesaurus is composed of 254 concepts organized into five levels

Besides technical issues raised by the development and maintenance of this thesaurus, such an initiative raises challenging questions in terms of validation of knowledge included in the e-library as information comes from different fields characterized by their own authoring and review procedures, but also from local experts who may not be familiar with protocols knowledge validation. Presently the validation largely relies on National Focal Points that act as intermediaries between local users and the central network, but this issue will certainly become critical if the experience keeps growing and attracting new knowledge providers. More research is required in studying the potential role of ontologies in the view of cross-comparative analysis and evaluation of urban policies and development cases.

4 Conclusions

Even though conceptualizations are not always strongly formalized in the field of urban development, various ontologies have been developed in this domain over the last few years. Arguably some of the most "formal" ontologies emerged from the construction sector, which can probably be explained by the risks, costs and time constraints associated with this sector.

As stated in our introduction, one of the aims of this COST Action is to raise new research issues in the field of ontologies and identify their potential role in urban development. We hence deliberately included in this book references to less formal experiences, characterized by a somehow different scope than the most "established ones". Besides usual interoperability and classification purposes, novel applications of ontologies have been identified. These typically include ontologies for tracking urban decision-making processes, urban knowledge sharing and reuse at a European level or spatial database reengineering for instance.

Another objective of this Action is to progressively identify research issues that would somehow be specific to urban ontologies. Amongst these we could state the requirement to address multi-stakeholders' views and offer support for a due public participation. Versatility of concepts over time contrasted with the stability/instability of the urban form is another specific issue that probably deserves further research. Finally the urban domain has often been viewed as a battleground between different scientific disciplines (geography, history, economy, architecture etc.) characterized by divergent ontologies. This has always been a source of discussion, confusion and stimulation for those interested in its conceptualization…

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