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Sharing Ontology in Complex Scenario using a Peer-To-Peer Approach *

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Abstract

The problem of defining efficient techniques for knowledge representation (KR) is becoming more and more a challenging topic in both academic and industrial community. The Semantic Web needs of formal knowledge representations for implementing useful services and put in common the different views between man and machines. In this framework, we assume that new approaches for knowledge definition and representation may be useful, in particular the ones based on the concept of ontology. We chose the issue of landscape planning as a case study, particularly focusing on cultural landscape. This choice was motivated by cultural and scientific innovations, which led in recent years to a completely new interpretation of landscape making it a high complex scenario. Based on these considerations, we propose a suitable ontology-based model and implement it in a system designed to manage ontologies using a peer-to-peer (P2P) paradigm to share general and domain knowledge. The network knowledge is exposed using a Web Service and it can be used by intelligent Web agents.

1 Introduction

The large amount of information on the internet and the needs of implementing a formal definition of knowledge representation require a more efficient and effectiveness techniques for mining the Web. In the last years some new approaches strictly related to the above matter have been proposed and one of them is the *Semantic Web* [10]. In this context, the concept of *relevance* about a given topic has a basic importance. In our study we are interested to the definition of relevance given by Schutz [64] according to him, it is defined as the aboutness of information to a theme namely to the specific aspect or object of our concentration, giving as base an horizon that is the stock of knowledge at hand. Therefore we must define models and techniques to represent and manage this knowledge. New techniques have been developed to solve those problems. Some of them are based on ontologies to delete or at least smooth conceptual or terminological mess and to have a common view of the same information. The ontological aspects of information are intrinsically independent from information representation, so the information itself may be isolated, recovered, organized and integrated with respect to its content. Moreover a central vision of the Semantic Web is that a user can cooperate with software applications using shared data and semantics. In this context intelligent applications interact with human agents to provide services. The ontological aspects of data need a hard work for formalizing its intrinsic knowledge. The ontology creation is a complex and hard consuming task therefore it is very important that these ontologies can be accessed and reused by more and more users and applications. According to [12] a distributed approach to Knowledge Management is useful for organizations and people which want to share "private knowledge". Moreover, from a technological point of view a P2P approach is particularly well suited, because it make possible for different participants (organizations, individuals, or departments) to maintain their own knowledge structure while exchanging information. Knowledge sharing is a complex task; in fact it entails both knowledge creation and knowledge reuse. These two activities are not orthogonal, as new knowledge builds on the re-use of existing knowledge. With this aim, knowledge sharing has three main tasks: (i) location of relevant explicit knowledge; (ii) selection of relevant/significant knowledge; and (iii) application of the knowledge in a particular context. In this context the notion of a community of practice [79] is of significant relevance. This approach

*Sections 1, 2, 6, and 7 are by both authors; sections 3 and Appendix A are by A. Cataldo; sections 4 and 5 are by A.M. Rinaldi.

is based on the idea that the knowledge can not be divided from the communities which create it.

We choose as case study issues related to the territorial planning sciences, in particular the ones about landscape planning. The territorial planning science concerns the process of managing and regulating the activities for territorial transformations. The output of territorial planning process is a set of rules and procedures used to narrow future actions; in other words it is a decision making process. In the context of territorial sciences, several subjects analyze particular territorial aspects; the territorial planning science could be seen as the discipline which completes, compares and organizes all that subjects. The step of analysis and understanding represents a key factor in the planning process because the actions for design, programming and control environment are based on knowledge. In the past, the meaning of landscape was related only to natural or cultural concepts with regards to human actions (historical heritage) but, in recent years, cultural and scientific innovations have led to a completely new interpretation of landscape, as a good to be preserved (since it is an expression of the ecological and social transformations of the territory resulting from the community's activities). From this point of view, the landscape has the distinguishing peculiarity of being characterized not only by just one category of elements (e.g., physical, natural, historical), but rather representing the totality of them. It represents a basic joint element between the human activities and the environmental system, where human abilities and skills represent the continuous research of a global eco-systemic balance. This significant innovation has been formalized with the drawing of the European Landscape Convention (ELC) [36], which is subscribed to by European Union Member States. Following this Convention "landscape means an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors". The aim of ELC is to put in evidence the main role of landscape quality because it is a fundamental element for people life. Therefore cultural and natural heritage acquire a key function in social and economic fields.

Once it is understood that the process of understanding the landscape is a priority and is propaedeutic for the definition of actions for its preservation, management, and planning, we need to identify those homogeneous territorial contexts that contain highly related and characterizing factors. Therefore, the process of knowledge acquisition about landscape starts from the recognition of its elements and from their interpretation depending on their context. To this end, we must try to resolve conceptual misunderstandings and semantic ambiguities and also to generate a precise and accurate description of our knowledge (in particular, of the terminologies representing the concepts that influence goals and describe actions to be implemented). In this context, the definition of a common and shared "language" is the first step in a formalization of knowledge on the topic of landscape. For this reason the landscape planning takes a great interest in the process of knowledge acquisition and representation finding novel approaches to implement CEP guidelines.

In this article we propose a methodology to formalize knowledge about cultural landscape recognizing its characteristic elements. On the other hand we formalize these concepts and identify shared meanings and their relationships.

In our vision we consider as a central point the formalization of a knowledge representation in a community. This community can build ontologies using formal models and techniques and share them in a P2P environment. We propose a novel logical model to define ontologies and we use a standard language to represent them. Using this model we develop domain ontologies (i.e., cutural landscape ontology) and we share them in a P2P network; with Web Service technology the network can show its knowledge to external agents for reusing.

The article is organized as follow: in the section 2 some related works are presented and discussed; a new methodology for landscape reading and interpretation is proposed in section 3 with the creation of our glossary; in section 4 the system architecture and its main functionalities are described; in section 5 we define and describe our model using OWL; a case study is presented in section 6; conclusion and future works are in section 7.

2 Theoretical Background

In this section we introduce some works related to our domain of interest in order to put in evidence the differences with our proposed method. In particular, we describe several systems and frameworks for knowledge sharing, experiences for landscape understanding, and approaches to formalize the knowledge using ontologies.

2.1 Systems

In the last years several approaches and systems have been presented to manage and share knowledge and in particular ontologies. In [6] is presented InfoQuilt, a system for sharing ontologies in a peer-to-peer environment. Using this system a user can find relevant sets of ontologies, reuse them, create new ones and advertise the resulting ontologies. The system allows to search concepts and services exploring inter-ontological relationships. The implemented system is based on agents that allow users to request information, semantically correlate data from different sources and of heterogeneous type or representation; they can have an interactive interface for knowledge discovery. Becker at al. [9] propose a P2P extension for ontology editing based on Ontorama [29]. The system uses a sharing protocol using RDF. This approach provides a novel editing environment compared to the classic client/server ontology management approaches. In [8] a method to integrate different knowledge sources as thesaurus, gazetteer and a chronology based in an ontology using Topic Maps is proposed. This ontology is shown to Government Agencies by Web Services to support information harmonization about environmental data. KAON [24] is an open-source software infrastructure to manage ontologies for semantic-driven applications. It integrates traditional technologies as relational databases with new knowledge representation tools. There are several additional components which increase the KAON functionalities. COE (Cooperative Ontology Editor) [39] is a P2P application designed to allow ontology developers to share their knowledge through many activities: ontology sharing, ontology reuse and other traditional peer-to-peer mechanisms. It is implemented over COPPEER, a framework for creating flexible collaborative P2P applications that provides nonspecific collaboration tools as plug-ins. SWAP (Semantic Web and Peer-to-Peer) [48] is a project that allows participants to keep private knowledge structures in their personal computer and share that knowledge in a P2P architecture. Users can extract ontologies from selected remote repositories, which are automatically integrated in their local repository. Any change in the source of the information is propagated to the local repositories. Oyster [58] is a java-based system, which assists users in managing, searching and sharing ontology metadata in a peer-to-peer network; it is a P2P application that exploits semantic web techniques in order to provide a solution for exchanging and re-using ontologies. The Oyster client on its own (e.g. disconnected from the P2P network) provides added value to it's users as it will give researchers an overview and search facilities of his/her own ontology metadata. In order to provide this functionalities, Oyster implements a proposal for a metadata standard, so called Ontology Metadata Vocabulary (OMV) which is based on discussions and agreement in the EU IST thematic network of excellence Knowledge Web as the way to describe ontologies. In [54] the authors propose an integrated agent system for ontology sharing on WWW, which enables users to manage ontologies and Semantic Web Services. The proposed system has several modules to meange personal information, translate them into standard language as RDF and analyze RDF to obtain user's interests and create Semantic Web Services which enable agent program to make inferences from grounding data on personalized ontology. In this context we notice also XAROP [16], a P2P platform to knowledge management in a decentralized IT infrastructure. Several surveys and books have been presented in the last years to evidence the importance of Peer-to-Peer and ontologies for enabling the Semantic Web; an useful reference is [69]. Moreover ontologies and P2P are also used in many other research topics: access and delivery of multimedia content over an interoperable environment [21], discovery data and services on WWW [83], locate data sources in a P2P environment and integrating domain ontology into common protocols [5], similarity search over widely distributed ultra-high dimensional data [23], Semantic Web [59, 66], and P2P networks [52, 80], intrusion detection systems [82], e-learning environment [60].

2.2 Experiences for landscape reading, interpreting, and representing

Several scientific and professional contributions on the national and international levels suggest a wide range of methodologies for landscape characterization and different procedures for assessing identified components.

Analyzing the existing literature (e.g., [27, 4, 43, 44, 20, 78, 61]), we notice that in the past different ways of characterizing the landscape were subordinate to specific cultural tendencies, different territorial realities, and particular planning requirements; they emphasized just one aspect of the landscape with respect to another one. As [17] noted, we range from natural morphology to the meaning given by men to this physical reality over time from human activities and interventions to the recognition of anthropic possession of places to the individualization of overall structures produced by communities at different times during the production and building of a territory. Briefly, the formalization and specification of landscape components have occurred in several European countries, but with different roots and characteristics. In [63], the authors argue that based upon the examination of international methods for landscape characterization and assessment, we can define six fundamental typologies. The process of landscape understanding is not limited only to recognizing its basic elements, but also involves their interpretation. In particular, the key step is to decode the elements meanings with respect to a specific context. Defining landscapes, specifically cultural landscapes, involves issues arising from the most generic interpretation of heritage. The heritage interpretation was first tackled at the end of the XIX century in the United States, but Tilden's work [70] was the first to lay the foundation for the discipline. In this work it is emphasized that the interpretation must succeed in showing “all” and not only a part. At present, different authors have addressed this subject and suggested different definitions (e.g., [28, 31, 2, 19, 3, 45, 53, 57, 22, 42]). Briefly, the interpretation is retained as an attractive communication, offers concise information, is linked to the presence of the object in question, and its purpose is to reveal meaning [28].

Moreover the interpretation is more than the simple transmission of knowledge. It aims to produce perceptions by making people feel new sensations. It is an act of communication established between a transmitter and receiver who do not share the same language code. To understand each other, therefore, they must ask for the mediation of interpretation. The message is then decoded. These considerations clearly show the extreme complexity of the concept of landscape, which is to be seen as a whole comprised of several parts (natural, anthropo-cultural, and perceptive); these parts must be interpreted in relation to their context.

The processes of reading and interpreting landscape need to represent the elements recognized in it.

At present, all studies on the landscape use a common graphical language both to survey it and to express its meanings. The landscape drawing (knowledge representation) is performed using different techniques: free-hand drawing, computer drawing, tri-dimensional models, perspective and axonometries, photography, etc. *Drawing* was the only language for communication, analysis, and synthesis.

The process of decoding landscape objects demonstrates the need for a new methodology for reading the landscape that takes into account the conceptual evolution of said landscape, the multi-disciplinarity of the subject and the interoperability. The importance of representing landscape with new languages related to this novel cultural approach is thus evident. These languages should allow the user to transmit the complexity of involved concepts and their meanings in the landscape context.

The development of an ontologically-based model of knowledge representation featuring universal terminology and basic criteria for information exchange will allow for the comparison of experiences in both a cultural and operational context.

2.3 Models and languages

From a generic point of view we can define a generic model for knowledge representation as composed by a triple $< S, P, C >$ [7], where: **S** is a set of objects; **P** is the set of properties used to link the objects in *S*; **C** is a set of constraints on *P*. One of the most important progress in the KR applications derived from proposing [51], studying [81],[13],[14] and developing [15],[37],[11] of languages for knowledge representation. Even if those languages have several differences they share some common aspects based on the specification of objects (concepts) and the relationships among them. The main features of all KR languages are: **Object-orientedness:** all information about a specific concept is stored in the concept itself (on the contrary, e.g., of rule-based systems). **Generalization/specialization:** these properties are basic aspects of the human cognition process [51]; the KR languages have mechanism to cluster concepts into hierarchies where the high-level concepts represent more general attributes than the low-level ones which inherit the general concepts attributes but are more specific, presenting additional features on their own. **Reasoning:** the capability of inferring the existence of information not explicitly declared by the existence of a given statement. **Classification:** given an abstract description of a concept, there are some mechanisms to determine if a concept can have this description. This feature is a special form of reasoning. Object orientation and generalization/specialization help human users in understanding the represented knowledge; reasoning and classification guide an automatic system in building a knowledge representation as the system knows what it is going to represent.

There are many points in common and several differences between our system and approach from the ones described before; in particular we propose a complete framework to manage, share and reuse ontologies. In addition our system has several features, such as editing functionalities and Web Service to share ontologies outside the P2P network. The several peers in our system have a general knowledge base as a support for knowledge organization together with a common model based on linguistic properties to build ontologies in order to have a common schema and a standard language for knowledge representation. In the landscape planning field, the use of a novel approach for representing and organizing knowledge is an innovation itself.

3 What to read and how to interpret: a methodological approach

In the previous sections, we have shown the need for new criteria and methodologies to read, interpret, and evaluate the characteristic signs of a landscape belonging to the past.

First, we should stress that landscape reading and interpretation lead to three basic questions. The first question refers to the territorial context: the discussion of landscape has an ontological nature and refers to several signifiers. The second question has a semiotic nature: the discussion of landscape is based on the representation of a territorial context (*the real world*) that consists of signs. The last and surely most theoretical question is epistemological and refers to *meanings* (concepts).

From a strictly operational view, these three questions reflect many procedures. All general territorial sciences, from geography to urban planning, start with the generation of a model of reality in order to evaluate the meaning given to things and then conclude with an intervention in the reality itself. *Signs*, *meanings*, and *signifiers* are the triad upon which the representation sciences are based, and these ideas are tightly connected with each other. A sign produces models of intervention; targets and values followed by a planner affect and boost the building of meanings; meanings determine the criteria and modalities of intervention, which will affect reality and will change it; changing the reality changes the meanings; different meanings imply different signs, which produce new representations of reality. Thus, to interpret or define a landscape is to translate and simplify the space complexity into decoded signs, meanings, and signifiers.

Giving a meaning to an object (signifier) is not an easy action. The meanings include two concepts suggested in [25]: a *denotative* element and a *connotative* element. To denote an object means to deduce the function (meaning) of said object (signifier); we have an immediate communication because the denotative meaning not lead to ideologies, meta-narrations, or meta-discussions. On the contrary, the meaning has a connotative function when it expresses an ideology in a potentially implicit or hidden way. According to Eco, for example, the connotation of an architectural work is "*the global ideology that has governed the architect's work*" [25]. It is the implicit meaning to which the sign leads. It is the meanings that refers to symbols, values, cultural products, and intangible culture.

Finally, we can assess the idea that through forms it is possible to recognize the story of objects, the things that remain from past societies. The analysis of signs requires a presupposition of the desire not to lose the traces and evidence of a surviving landscape. The analysis is propaedeutic to all policies of safeguard or planning-management, because a landscape never changes entirely, but instead transforms by altering its elements [65]. Any object of a landscape, once recognized, gains the value of a sign. The sign should not simply be recognized as it is, but should be interpreted.

The interpretation of landscape signs should not be limited only to recognizing single elements (through decomposing praxis), but instead should refer to the context to which the signs belong (relationship with the whole) or the ways in which they have meaning and functionality. The reading of landscape signs should not be targeted to the rebuilding (recovery) of a given landscape, but should instead be undertaken in order to understand the meaning of signs themselves. This will allow us to place them into planning interventions as living objects that are suitable for the context and present needs. We can thus integrate two fundamental needs for territorial organization: the need for reassessment and the need for conservation of identified landscapes [26, 71]. The denotative and connotative meanings of an object are the starting points for the interpretation of the landscape concept expressed by the European Convention. The assumption that a landscape is a determined part of a territory where man and nature operate allows the objects (landscape elements) to be considered in their material form as a group of physical, ecological, economic, and social signs to be interpreted. The image of a landscape represents the beginning of a knowledge route targeted to explain the function of the objects characterizing a place. Moreover, the Convention also underlines the idea that the portion of the territory should be considered as it is perceived by the population. This implies that the interpretation of the objects transcends their functional and material characteristics to include the analysis of the symbols and values given to the places.

Landscape interpretation is also affected by the duality between local and global regions. By pursuing the exploitation of local identities, it may be necessary to refer to specific contexts and involve communities in the process (and also symbolic meanings of landscape recognition; on the other hand, it clearly expresses the desire to find a common language leading to landscape recognition. According to this interpretation, it is possible to define general criteria and intervention modalities.

3.1 An interpreting hypothesis of the Cultural Landscape

The recent European Union policies give great importance to the cultural landscape. Indeed, no precise definition of cultural landscape exists in the European documents (although a definition can be deduced from reading the documents themselves). In most cases, a cultural landscape is set up in contrast to a natural one. Therefore, we can infer that it represents the landscape formed by the signs expressed by human beings. It is a tangible expression of the culture of its past and present dwellers. This is a concept similar to the anthropological idea of the "*tangible culture of a civilization*" [18], which can be expressed as either a historical "*document-monument*" [46], or an "*artificial memory*" [47].

Moreover, the nature-culture distinction is no longer acceptable since human intervention can be found everywhere. From this point of view, the natural elements become part of the cultural sphere. The landscape plays a cultural role not only via the signs left by men on it, but also through the meaning given to it. Therefore, the nature is so full of meaning and value, it becomes a completely cultural phenomenon. Of course, the term cultural is not intended to mean tangible culture (anthropic evidence), but rather culture in the semiotic sense. According to this idea, "*all the landscape, independently from the fact that it has been settled or is actually settled, is phenomenon of meaning and so culture*" [68]. Thus, any atrophic-geographic landscape has a cultural meaning since it represents the heritage of situations, functions, and phenomena that have occurred and followed each other in the course of time. This process has left evidence that can be interpreted as the expression of the culture that produced it.

Landscape, as Salzano [62] says, can be interpreted as "*the historical product of human culture and work on nature.*" (see also [74, 42]). In addition, the international documents foster the symbiosis between landscape and cultural heritage. In fact, some international documents confuse the two words and use them almost as synonyms.

Considering cultural landscape in the above way, the study and interpretation of landscape becomes wider and richer in meaning since we do not restrict our set of signifiers to those signs left by man on the territory.

3.2 The definition of a glossary for signifiers formalization in cultural landscape

In the process of ontology development, building a *glossary of terms* can be seen as a first step toward landscape interpretation, or rather as a first attempt to formalize a shared knowledge. The sharing process is one of the harder issues both in our context and, generally speaking, in the process of ontology formalization. This difficulty has been solved by finding an explicit consensus in the expert's community.

Therefore, the choice of signifiers and meanings related to the cultural landscape arises from the analysis of shared international documents and legal tools that directly or indirectly affect the landscape itself [75, 32, 41, 33, 74, 36, 76, 77, 42, 73, 34]. In this way, we define all the elements that characterize landscape, the relations between them, and their connotative and denotative meanings. We stress that almost all of the Charters and Conventions on this subject include a space designated for definitions. In most cases, the meanings given are connotative in nature and express ideologies and themes concerning practices of good governance. Landscape planning, cultural policies, and measures, conservation, protection, repairs, and safeguards are among the concepts expressed in those documents, and their meanings are addressed to targets of landscape quality. They define the meanings of the concepts that can be considered as cornerstones of the cultural route followed through time by the theory of territorial, environment, and landscape planning. They specify the meaning of cultural expression, cultural diversity, inter-culture, authenticity, and identity, as well as those more strictly connected with the natural sphere (e.g., biological diversity, ecosystem, and habitat).

Apart from the epistemological contribution of an explanation of the meanings (concepts) linked to the theory of landscape planning, the international documents offer a satisfying ontological framework based on the definition of the meanings. Using the proposed methodology, all these components with their specializations (i.e., signifiers and meanings) have been arranged in a complete glossary and shown in specific tables (7,5,6,7,8) and graphs (7,8,9,10,11) presented in Appendix A.

From a methodological point of view, the glossary has been divided into five basic parts with figures and tables. In these tables the concepts, their meanings (definitions), and references are reported. On the other hand, the figures demostrate each concept together with its relations with the other concepts. In the first part of the glossary (see Table 7 and Figure 7) we show general concepts about landscape and measures to manage it, as defined in ELC. In order to formalize the elements of a *cultural landscape* (see Table 5 and Figure 8) we worked out a hierarchical systematization. Upon reading the documents, we first identified meanings adaptable to any cultural context. Then, we formalized the meanings related to objects like cultural monuments, cultural sites, cultural industries, activities, cultural goods, and services. Later, the cultural landscape was investigated with different typologies: the *human-cultural heritage*, *natural heritage*, and *rural landscape*. The key idea is that the forms of a cultural landscape arise from the territorial physical structure as well as several rules surrounding the use of social energy to transform the territorial structures following each other over the course of time. We should therefore consider productive activities as well as those elements belonging to a man-made territory (e.g., historical nuclei, architectural models, and buildings).

In summary, the reading of a cultural landscape refers to three closely connected aspects: the historical point of view and landscape development over the course of time; the facets linked to the landscape's shape; the functional and anthropic facets (e.g., use of soil, settlements, infrastructure).
Specifically with regard to *human-cultural heritage* (see Table 6 and Figure 9), we considered the elements of architectural and building heritage, intangible heritage, and the historical centers that include both of these. The meanings given to the objects in this case are denotative, and they aim to express the function of the object itself. With regard to *natural heritage* (see Table 7 and Figure 10), the biological resources, monuments, natural areas, and sites have been defined along with their geomorphological facets. Finally, *rural landscape* (see Table 8 and Figure 11) has been considered as the expression of the connection between human activities and the environment; in these landscapes, human capabilities and skills develop in a never-ending search for balance. They express the functional evolution occurring over the course of time, which evolution is linked to the work techniques, manner of dwelling, natural dynamics, and social conditions. These are landscapes produced over a long adjustment period that finally reaches the ecological essentiality and stability given of the man-nature compromise. From this point of view, landscapes require the analysis of those elements characterizing both natural landscapes and anthropic heritage. To formalize the meanings of rural landscapes, therefore, we referred to ecological (e.g., forests, hydrography, semi-natural areas) and anthropic (e.g. use of soil, cultivated land, settlements, infrastructure) factors related to the functional aspects of these areas.

4 System architecture

The proposed system has several software modules and, form a top-level view, they can be organized around some entities and macro-functionalities. The main entities in our system are: **Peer**–it is the the agent in charge of editing and manage ontologies; each user which takes part in the network is a peer. **Rendez-Vous Peer**–its task is to build the P2P network and manage a list of sharing ontologies between peers and Web Service. **Web Service**–it exposes the ontologies out of the P2P network.

In the following we describe the general architecture of our system. Figure 1 draws the proposed system architecture; an example of the single macro-modules in each peer is also shown.

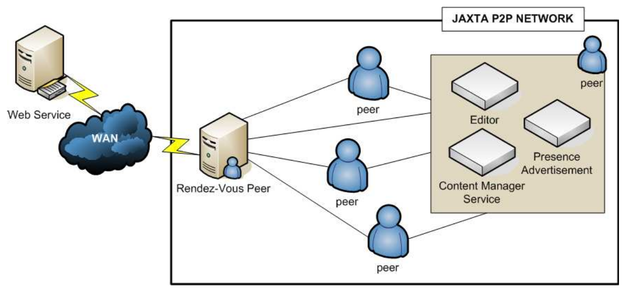

Figure 1. The system architecture

As we can argue from figure 1, a peer has two main tasks: (i) managing and editing local ontologies and (ii) putting in share local ontologies. The Rendez-Vous peer has a list of active peers and a description of their contents. It uses these information in the knowledge discovery step both between peers and in the sharing phase with Web Service. In each single peer a system interface shows the catalog of the ontology stored in the ontology repository (i.e. a relational DB) to the user by means of an appropriate software module called OntoSearcher; OntoSearcher performs a syntactic search or a browsing in a directory structure arranged by arguments to the aim of finding an ontology relevant to the user interest. When OntoSearcher finds a suitable ontology, the OntoViewer builds a graph (a semantic network) to represent the ontology. A user can modify the semantic network or build a new one with the peer editing functionalities. On the other hand a peer must communicate to the other peer and with the Rendez-Vous one for sharing ontologies. We use as framework to build our P2P network, JXTA which uses advertisement in the communication steps. In the following subsections we describe into details both the remaining modules drawn in figure 1 and the algorithm used to build dynamically the semantic network.

4.1 Ontology Extraction and Editing

In our approach we use an appropriate algorithm to extract from WordNet [50] (the system knowledge base) a domain semantic network; this net provides a general representation of our domain of interest.

Many information systems use a knowledge base to represent data in order to satisfy information requests and in our vision it is a good choice for having a common view of the same general and specific knowledge domain. Moreover in our framework WordNet can be a “starting point” for users because they can extract an initial general ontology from this knowledge base and expand it to have a specialized one; these tasks are explained in the following of this section.

We implement our ontology by means of a semantic network. This structure is often used as a form of knowledge representation: it is a graph consisting of nodes which represent concepts and edges which represent semantic relations between the concepts. If the users domain of interest is not in the Ontology Repository, they can build an ontological domain using WordNet. This step is performed by the OntoExtractor which is in charge of extract an ontology (i.e. a semantic network).

We propose a dynamic construction of the semantic network using an ad hoc algorithm which takes into account the WordNet structure.

WordNet organizes the several terms using their linguistic properties. Moreover, every domain keyword may have various meanings (senses) due the proprieties of polysemy, so a user can choose its proper sense of interest using the tool interface. Beyond the synonymy, we consider other linguistic proprieties applied to the typology of the considered terms in order to have a strongly connected network.

Our network is built starting from a domain keyword that represents the context of interest for the user. We then consider all the component synsets and construct a hierarchy, only based on the hyponymy property; the last level of our hierarchy corresponds to the last level of WordNet one. After this first step we enrich our hierarchy considering all the other kinds of relationships in WordNet (see table 1). Based on these relations we can add other terms in the hierarchy obtaining a highly connected semantic network.

Clearly, even if a knowledge base could be large and detailed, it will never give us a high level of specialization for every existing knowledge domains. Our approach tries to give a solution to this problem. In fact users can interact with our system in order to create a first ontological knowledge representation or they can expand it or create a new one using the OntoEditor module. Using the OntoEditor functionalities a user can modify the ontology structure as a whole adding new terms and concepts in the network, linking terms and concepts using arrows (lexical and semantic properties), deleting nodes and arcs. All the ontologies can be exported in OWL following a schema model described in section 5. The interaction with the semantic network using the editing tools is archived by means of Java 3D libraries.

The algorithm to extract the semantic network from WordNet is described in pseudo-code in figure 2.

```
//-------------------------------------------------------
// Semantic network extraction algorithm
//
// INPUT: Main_Synset:
// represents the synset chosen by user
//
// OUTPUT: Synset_List:
//  the list returned from the function.
//        It contains all DSN synsets
//-------------------------------------------------------
Synset_List   CreateDSN (Main_Synset)
{
  Add Main_Synset to a Synset_List
  Load from Wordnet the Category_terms of Main_Synset
  Add founded synsets to Synset_List
  While (Synset_List is not_empty)
  Do {
   Load from Wordnet all hyponyms of all synsets
     in Synset_List
   Add founded synsets to Synset_List
  }
  Start from head_list
  While(Synset_List is not_empty)
  Do {
   Load from Wordnet all synsets linked to all synsets
     in Synset_List using all other linguistic
     properties (count outhyponimy and hyperonimy)
  }
  return Synset_List
}
```

Figure 2. Semantic network extraction algorithm

4.2 Advertisements and Sharing

The other main functionality of the peer system is the ability of sharing knowledge using ontology. This system feature is obtained using advertisements and ad hoc modules. The advertisement are XML metadata file.

We use a Content Manager Service (CMS) to manage the ontology files. It is a inter-layer between JXTA and the application layer; in it we have discovery and pipe services to implement sharing and downloading tasks. The Presence Advertisement module manages some types of advertisements related to general info about peers and ontologies.

These advertisements are key information for the Rendez-Vous Peer; in fact this peer is a collector of all advertisements and store it in its internal cache. That information are collected in a list used for knowledge discovery in the P2P network and exported to external agents via a Web Service.

In the following an example of Ontology Advertisement about the use case described in section 6 is shown.

```
<peerID>
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5 The ontology Model

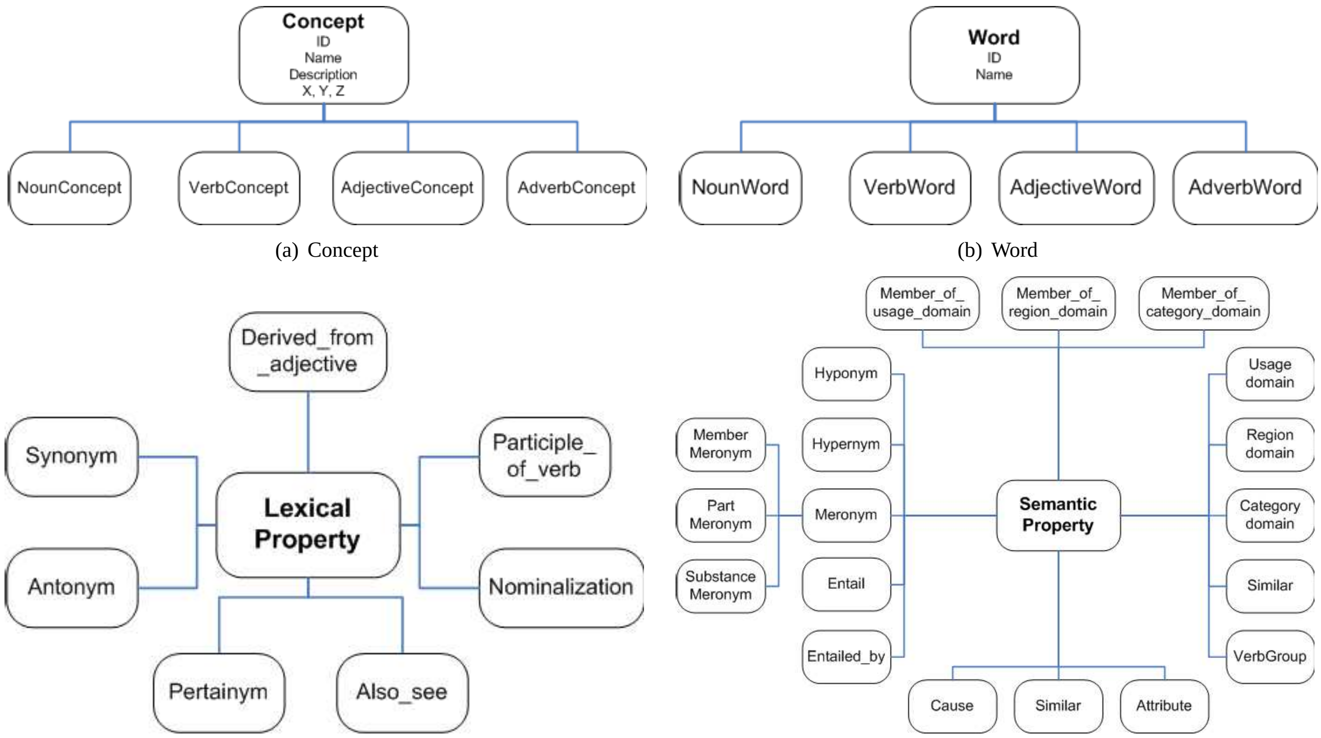
The system has a common model for defining ontologies. In this way all peers have a common view of distributed knowledge and can share it in a simple way. The adoption of this model can help external agents (outside the P2P network) to use the ontologies for their purpose. In our approach the knowledge is represented by an ontology implemented by a semantic network.

A formal definition of ontology is proposed in [40] where *conceptualization* refers to an abstract model of a specific reality in which the component concepts are identified; *explicit* means that the type of the used concepts and the constraints on them are well defined; *formal* refers to the ontology propriety of being “machine-readable”; *shared* refers to the fact that an ontology captures the consensual knowledge, accepted by a group of persons. We also consider other definitions of ontology found in [55]. This definition indicates the way to proceed in order to construct an ontology: i) identification of the basic terms and their relations; ii) agreement on the rules to arrange them; iii) definition of terms and relations between concepts. From this perspective, an ontology includes not only the terms that are explicitly defined in it, but also those that can be derived using defined rules and properties. Thus an ontology can be seen as a set of “terms” and “relations” among them, denoting the concepts that are used in a specific domain.

In this context we consider words, the defined properties are the linguistic ones and the constraints are the roles of validity applied on linguistic properties with respect to the considered term category. A concept is a set of words which represent an abstract idea.

In the last years several languages have been proposed to represent ontologies; one of the most used is OWL. We use the DL (Description Logic) version of OWL because it has enough effectiveness to describe the ontology.

The DL version allows the declaration of disjoint classes which are used, for example, to assert that a word belongs to a syntactic category. Moreover it allows the declaration of union classes used to specify domains and property ranges to relate concepts and words belonging to different lexical



(a) Concept (b) Word

(c) Lexical Properties (d) Semantic Properties

Figure 3. Concept, Word and Linguistic properties

categories. Every node, both concept and word, is an OWL individual. The connecting edges in the ontology are represented as *ObjectProperties*.

These properties have some constraints that depend on the syntactic category or on the kind of property (semantic or lexical). For example the hyponymy property can relate only nouns to nouns or verbs to verbs; on the other hand a semantic property links concepts to concepts and a syntactic one relates word forms to word forms.

Concept and word attributes are considered with *DatatypeProperties*, which relate individuals with a predefined data type. Each word is related to the represented concept by the ObjectProperty *hasConcept* while a concept is related to words that represent it using the ObjectProperty *hasWord*. These are the only properties able to relate words with concepts and vice versa; all the other properties relate words to words and concepts to concepts.

Concepts, words and properties are arranged in a class hierarchy, resulting from the syntactic category for concepts and words and from the semantic or lexical type for the properties. Figures 3(a) and 3(b) show that the two main classes are: Concept, in which all the objects have been defined as individuals and Word which represents all the terms in the ontology.

The subclasses have been derived from the related categories. There are some union classes useful to define properties domain and codomain. We define some attributes for Concept and Word respectively; Concept has: *Name* that represents the concept name; *Description* that gives a short description of concept. On the other hand Word has *Name* as attribute that is the word name. All elements have an *ID* within the WordNet offset number or a user defined ID.

The semantic and lexical properties are arranged in a hierarchy (see figure 3(c) and 3(d)).

In table 1 some of the considered properties and their domain and range of definition are shown.

Table 1. Properties

Property	Domain	Range
hasWord	Concept	Word
hasConcept	Word	Concept
hypernym	NounsAnd VerbsConcept	NounsAnd VerbsConcept
holonym	NounConcept	NounConcept
entailment	VerbWord	VerbWord
similar	AdjectiveConcept	AdjectiveConcept

The use of domain and codomain reduces the property range application. For example the hyponymy property is defined on the sets of nouns and verbs; if it is applied on the set of nouns it has as range the set of nouns, otherwise if it is applied to the set of verbs it has as range the set of verbs.

In table 2 there are some of defined constraints and we specify on which classes they have been applied w.r.t. the considered properties; the table shows the matching range too.

Table 2. Model constraints

Costraint	Class	Property	Constraint range
AllValuesFrom	NounConcept	hyponym	NounConcept
AllValuesFrom	AdjectiveConcept	attribute	NounConcept
AllValuesFrom	NounWord	synonym	NounWord
AllValuesFrom	AdverbWord	synonym	AdverbWord
AllValuesFrom	VerbWord	also_see	VerbWord

Sometimes the existence of a property between two or more individuals entails the existence of other properties. For example, being the concept dog a hyponym of animal, we can assert that animal is a hypernymy of dog. We represent in OWL this characteristics by means of property features shown in table 3.

Table 3. Property features

Property	Features
hasWord	*inverse* of hasConcept
hasConcept	*inverse* of hasWord
hyponym	*inverse* of hypernym; *transitivity*
hypernym	*inverse* of hyponym; *transitivity*
cause	*transitivity*
verbGroup	*symmetry* and *transitivity*

6 The Case Study

We describe and test our methods and techniques with a complete use case in order to put in evidence the several features of the proposed model and implemented system. The system has been completely implemented using Java. We remind that the P2P network is obtained using JXTA libraries while the Web Service uses the AXIS framework. The P2P network is built starting from the first peer which creates a group and defines itself as Rendez-Vous Peer. The JXTA framework uses internal advertisements to represent network resources (i.e PeerGroup, pipe and services). When a peer wants to enter in a group an advertisement specifying some information about it must be sent to the Rendes-Vouz Peer. When it wants share resources, other types of advertisement are sent and collected by Rendes-Vouz Peer. We define a personalized advertisement managed by the Presence Advertisement module to have a more punctual description of our ontologies. These advertisements, called *Ontology Advertisements*, are stored in the Rendes-Vouz Peer cache. They are used for ontology discovery in the P2P network and arranged in a list for the Web Service to expose the available ontologies out to the P2P network. Using the windows tabs shown in figure 4, a user can analyze the network and peer activities checking the log file in the Main Tab, share ontologies exploring its folders, create Ontology Advertisements, search and download ontologies using advertisements metadata.

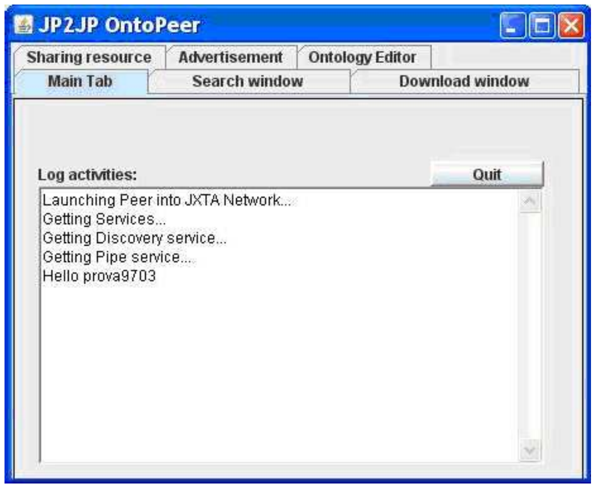


Figure 4. Peer Management Interface

A user interacts with the system editing tools using an ad hoc interface is shown in figure 5. We choose as motivating example the building of ontology in territorial planning research field and in particular about cultural landscape.

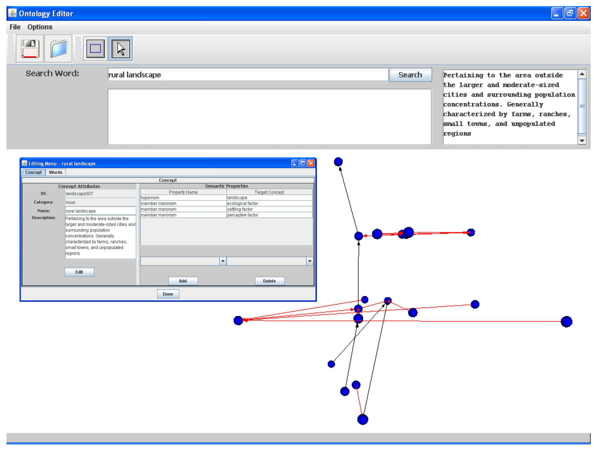


Figure 5. Editor Interface

This choice is motivated by cultural and scientific innovations that have led in recent years to a completely new interpretation of landscapes. This field is a hot topic in that research community due to its intrinsic complexity, and the authors are collaborating in an EU COST project [1].

In the ontology pre-consensus step, we define our glossary (see Section 3.2) using well-known knowledge sources mentioned above. In this way, we provide a more detailed description of the variables affected by several situations related to our field of interest. A specific ontology for *cultural landscapes* is created ex novo using this glossary.

The complete glossary is provided in Appendix A with sketches of ontology conceptual graphs about cultural landscape (see Figures 7,8,9,10,11). These graphs give a high-level description of ontology structure, concepts in it and relations between them.

The related elements and phenomena are individuated by applying disaggregating and re-aggregating processes to the cultural landscape components. The cultural landscape image is described by means of its natural (ecological) factors, built-up (settling) factors, and visual and perceptive factors. All of these macro-categories are arranged in classes, which in turn have been divided into features and variables. A general ontology regarding the landscape was successively extracted from WordNet following the steps described in Section 4.1, starting from the keyword *region(sense3): a large, indefinite location on the surface of the Earth*.

The process of extracting an ontology from WordNet begins with an interaction in which the user inserts a specific term (e.g. region) by means of the user interface and chooses the proper sense by reading the description of the related concepts. The system obtains the correct sense and builds the ontology by following the steps described in the previous section. We chose to link the new proposed concept of landscape (*an area perceived by people whose character is the result of the action and interaction of natural and/or human factors* [36]) directly to the region synset to use it as a bridge for ontology merging.

Therefore, we expanded this ontology by providing more information about the cultural landscape (see Figure 5).
Using our tool, we have the OWL representation shown in Figure 6.

The built ontology is shared in the network by peer owner using the Peer Management Interface described before.

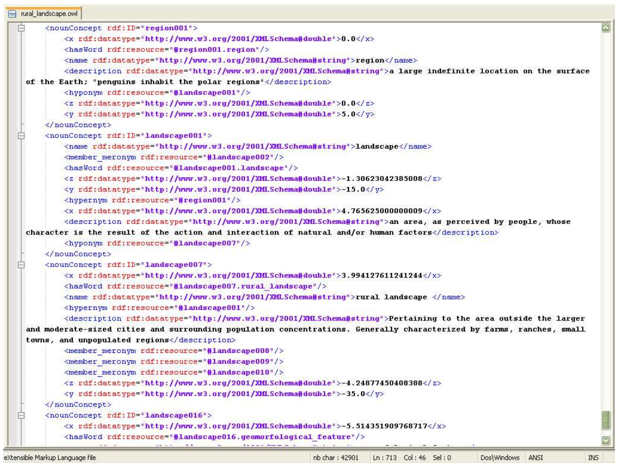


Figure 6. Owl representation of cultural landscape ontology

7 Conclusions and Future Works

The sharing and reuse of existing ontologies is a non trivial task. A P2P approach allows the creation of knowledge communities in which information can be shared and reused in an effective way. Moreover the specialized knowledge in the local communities should be used by other sentient agents to perform their tasks in a more accurate way.

On the other hand the needs of formal ontologies for knowledge representation involve several aspects of knowledge engineering and sharing systems.

In this article we have proposed a global approach to solve these problems; we implemented a system for sharing and creating ontologies in a P2P network, the network knowledge is exported out using a Web Service. Our system uses a simple and general model for knowledge representation taking into account a linguistic approach considered as the natural communication way between human agents. The ontologies are represented using OWL.

We want to point out that, from a general point of view, we have an evolution of concepts during time; this is a cause of *knowledge obsolescence*, so there is the need for a continuous updating. In WordNet, for example, the concept of *landscape* is related only to a *visual appearance* dimension. Moreover in all fields of knowledge the research innovation allows the definition of new concepts. For example the concept of *rural landscape* does not exist in WordNet; this lack needs of a knowledge expansion.

Other issues need to be investigated, such as a solution to the ontology mismatch problem and the definition of an algorithm for automatic ontology merging to integrate peer domain ontologies in general knowledge bases used by intelligent agents on the Web.

APPENDIX A: Glossary

In this appendix, we provide the defined glossary (see Section 3.2), divided into its main parts. For each of the glossary tables, we provide a graph of concepts and relations to better represent the related ontology: the darkest nodes are the main concepts and the bold edged nodes represent concepts that are shared between single glossary parts (these concepts are repeated through the glossary tables). The description of each concept is provided in the glossary tables. We argue that choosing definitions from international documents gives a high level of agreement; this is a basic condition for building an ontology. Since there are very similar definitions in the analyzed documents, the authors chose to use the more reliable definition in the research community. Note that the whole glossary was used to build the ontology, and all single concepts and words were arranged following the model rules defined in Section 5. We recognized 62 new concepts and 49 relations between them.

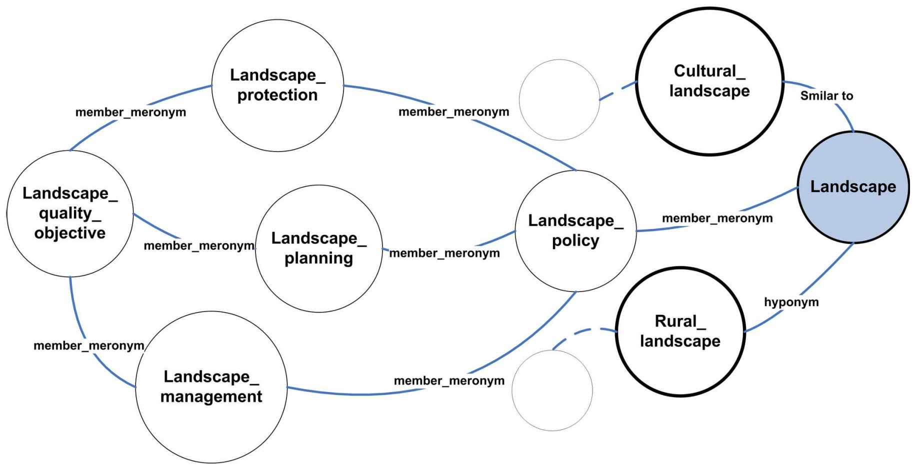


Figure 7. A portion of the Landscape Ontology Graph

Concept	Description	Reference
Landscape	An area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors	[33]
Landscape policy	An expression by the competent public authorities of general principles, strategies and guidelines that permit the taking of specific measures aimed at the protection, management and planning of landscapes	[33]
Landscape quality objective	For a specific landscape, the formulation by the competent public authorities of the aspirations of the public with regard to the landscape features of their surroundings	[33]
Landscape protection	The actions to conserve and maintain the significant or characteristic features of a landscape, justified by its heritage value derived from its natural configuration and/or from human activity	[33]
Landscape management	The action, from a perspective of sustainable development, to ensure the regular upkeep of a landscape, so as to guide and harmonize changes which are brought about by social, economic and environmental processes	[33]
Landscape planning	A strong forward-looking action to enhance, restore or create landscapes	[33]

Table 4: Landscape Glossary

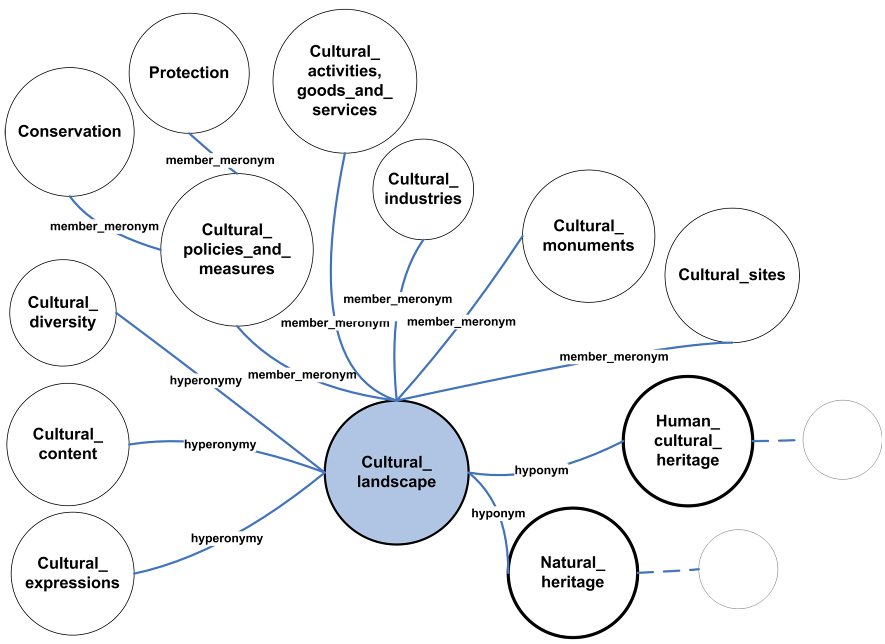


Figure 8. A portion of the Cultural Landscape Ontology Graph

Concept	Description	Reference
Cultural landscape	Landscapes as cultural heritage result from and reflect a prolonged interaction in different societies between man, nature and the physical environment. They are testimony to the evolving relationship of communities, individuals and their environment. In this context their conservation, preservation and development focus on human and natural features, integrating material and intangible values	[67]
Cultural diversity	The manifold ways in which the cultures of groups and societies find expression. These expressions are passed on within and among groups and societies. Cultural diversity is made manifest not only through the varied ways in which the cultural heritage of humanity is expressed, augmented and transmitted through the variety of cultural expressions, but also through diverse modes of artistic creation, production, dissemination, distribution and enjoyment, whatever the means and technologies used	[70]
Cultural content	The symbolic meaning, artistic dimension and cultural values that originate from or express cultural identities are those expressions that result from the creativity of individuals, groups and societies, and that have cultural content	[70]
Cultural expression	An expression that results from the creativity of individuals,groups and societies, and that have cultural content	[70]
Cultural activities, goods and services	Activities, goods and services,which at the time they are considered as a specific attribute, use or purpose, embody or convey cultural expressions, irrespective of the commercial value they may have. Cultural activities may be an end in themselves, or they may contribute to the production of cultural goods and services	[70]
Cultural industry	An industry producing and distributing cultural goods or services	[70]
Cultural Site	A work of man or the combined works of nature and of man, and areas including archaeological sites which are of outstanding universal value from the historical, aesthetic, ethnological or anthropological points of view	[68]
Cultural Monument	An architectural work, works of monumental sculpture and painting, elements or structures of an archaeological nature, inscriptions, cave dwellings and combinations of features, which are of outstanding universal value from the point of view of history, art or science	[68]
Groups of buildings	Groups of separate or connected buildings which, because of their architecture, their homogeneity or their place in the landscape, are of outstanding universal value from the point of view of history, art or science	[68]
Cultural policies and measures	Policies and measures relating to culture,whether at the local, national, regional or international level that are either focused on culture as such or are designed to have a direct effect on cultural expressions of individuals, groups or societies, including on the creation, production, dissemination,distribution of and access to cultural activities, goods and services	[70]
Protection	The adoption of measures aimed at the preservation, safeguarding and enhancement of the diversity of cultural expressions	[70]
Conservation	The complex of attitudes of a community that contributes to making the heritage and its monuments endure. Conservation is achieved with reference to the significance of the entity, with its associated values	[67]
Interculturality	The existence and equitable interaction of diverse cultures and the possibility of generating shared cultural expressions through dialogue and mutual respect	[70]
Human cultural heritage	The complex of man's works in which a community recognizes its particular and specific values and with which it identifies. Identification and specification of heritage is therefore a process related to the choice of values	[67]
Monument	An entity identified as of worth and forming a support to memory. In it, memory recognizes aspects that are pertinent to human deeds and thoughts, associated with the historic time line. This may still be within our reach, even though not yet interpreted	[67]
Site	The combined works of man and nature, being areas which are partially built upon and sufficiently distinctive and homogeneous to be topographically definable and are of conspicuous historical, archaeological, artistic, scientific, social or technical interest	[29]
Authenticity	The sum of substantial, historically ascertained characteristics: from the original up to the current state, as an outcome of the various transformations that have occurred over time	[67]
Identity	The common reference of both present values generated in the sphere of a community and past values identified in its authenticity	[67]
Restoration	An operation directed on a heritage property, aiming at the conservation of its authenticity and its appropriation by the community	[67]
Project of restoration	The project, resulting from the choice of conservation policies, is the process through which conservation of the built heritage and landscape is carried out	[67]
Architectural heritage	An entity with the following permanent properties: the monuments, groups of buildings and sites to be protected. The architectural heritage constitutes an irreplaceable expression of the richness and diversity of Europe's cultural heritage, bears inestimable witness to our past and is a common heritage of all Europeans	[29]

Table 5: Cultural Landscape Glossary

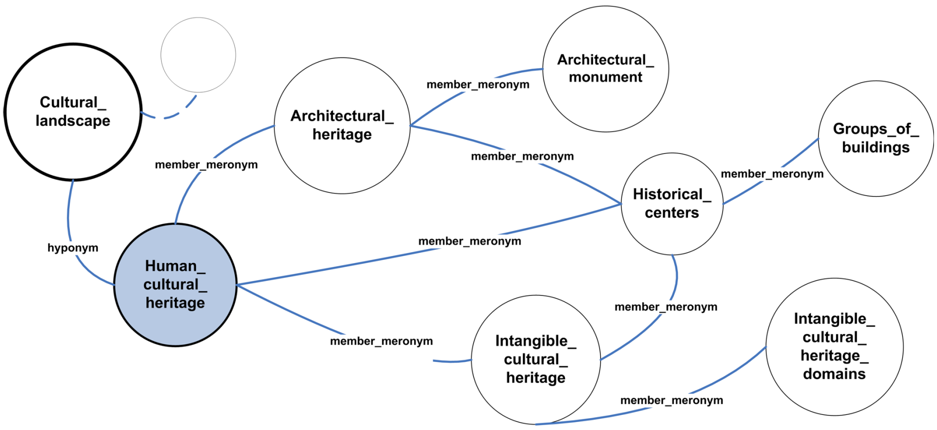


Figure 9. A portion of the Human Cultural Heritage Ontology Graph

Concept	Description	Reference
Heritage	The complex of man's works in which a community recognizes its particular and specific values and with which it identifies. Identification and specification of heritage is therefore a process related to the choice of values	[67]
Cultural-Anthropic Monument	An entity identified as of worth and forming a support to memory. In it, memory recognizes aspects that are pertinent to human deeds and thoughts, associated with the historic time line. This may still be within our reach, even though not yet interpreted	[67]
Site	The combined works of man and nature, being areas which are partially built upon and sufficiently distinctive and homogeneous to be topographically definable and are of conspicuous historical, archaeological, artistic, scientific, social or technical interest	[29]
Authenticity	The sum of substantial, historically ascertained characteristics: from the original up to the current state, as an outcome of the various transformations that have occurred over time	[67]
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Restoration	An operation directed on a heritage property, aiming at the conservation of its authenticity and its appropriation by the community	[67]
Project of restoration	The process, resulting from the choice of conservation policies, through which conservation of the built heritage and landscape is carried out	[67]
Architectural heritage	An entity with the following permanent properties: the monuments, groups of buildings and sites to be protected. The architectural heritage constitutes an irreplaceable expression of the richness and diversity of Europe's cultural heritage, bears inestimable witness to our past and is a common heritage of all Europeans	[29]
Architectural monument	A building and structures of conspicuous historical, archaeological, artistic, scientific, social or technical interest, including their fixtures and fittings	[29]
Groups of buildings	A homogeneous groups of urban or rural buildings conspicuous for their historical, archaeological, artistic, scientific, social or technical interest which are sufficiently coherent to form topographically definable units	[29]
Historical center	A human living settlement, strongly affected by a physical structure coming from past, recognizable as symbolical of a community evolution	[65]
Intangible cultural heritage	The practices, representations, expressions, knowledge, skills as well as the instruments, objects, artefacts and cultural spaces associated therewith that communities, groups and, in some cases, individuals recognize as part of their cultural heritage. This intangible cultural heritage, transmitted from generation to generation, is constantly recreated by communities and groups in response to their environment, their interaction with nature and their history, and provides them with a sense of identity and continuity, thus promoting respect for cultural diversity and human creativity	[69]
Intangible cultural heritage domains	The "intangible cultural heritage" is manifested inter alia in the following domains: oral traditions and expressions, including language as a vehicle of the intangible cultural heritage; performing arts; social practices, rituals and festive events; knowledge and practices concerning nature and the universe; traditional craftsmanship	[69]
Intangible cultural heritage safeguarding	The measures aimed at ensuring the viability of the intangible cultural heritage, including the identification, documentation,research, preservation,protection, promotion, enhancement, transmission, particularly through formal and non-formal education, as well as the revitalization of the various aspects of such heritage	[69]

Table 6: Human-Cultural Heritage Glossary

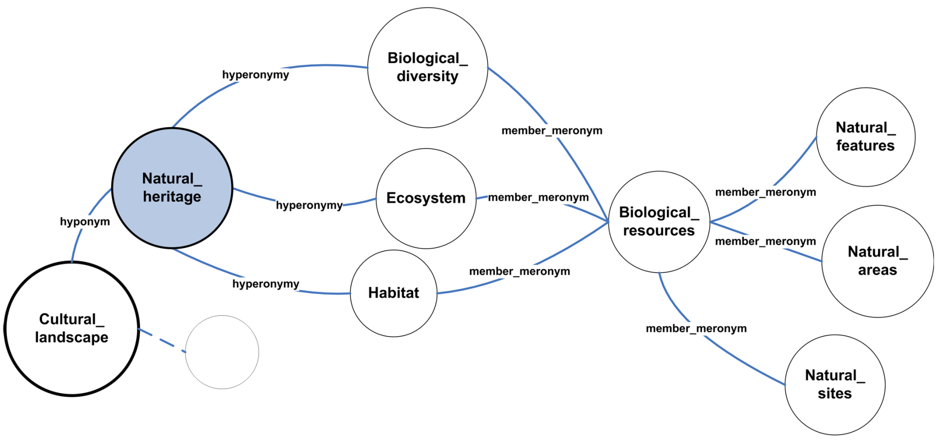

Figure 10. A portion of the Natural Heritage Ontology Graph

Concept	Description	Reference
Natural Heritage	An entity defined by physical, biological, and geological features; habitats of threatened plants or animal species and areas of value on scientific or aesthetic grounds or from the point of view of conservation	[68]
Natural feature	A physical and biological formation or groups of such formations, which are of outstanding universal value from the aesthetic or scientific point of view	[68]
Natural area	A Geological and physiographical formation and precisely delineated areas which constitute the habitat of threatened species of animals and plants of outstanding universal value from the point of view of science or conservation	[68]
Natural site	An entity with universal value from the point of view of science, conservation or natural beauty	[68]
Biological diversity	The variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems	[66]

biological resource	A genetic resource, organism or parts thereof, populations, or any other biotic component of ecosystems with actual or potential use or value for humanity	[66]
domesticated or cultivated specie	A specie in which the evolutionary process has been influenced by humans to meet their needs	[66]
Ecosystem	A dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit	[66]
habitat	The place or type of site where an organism or population naturally occurs	[66]
protected area	A geographically defined area which is designated or regulated and managed to achieve specific conservation objectives	[66]

Table 7: Natural Heritage Glossary

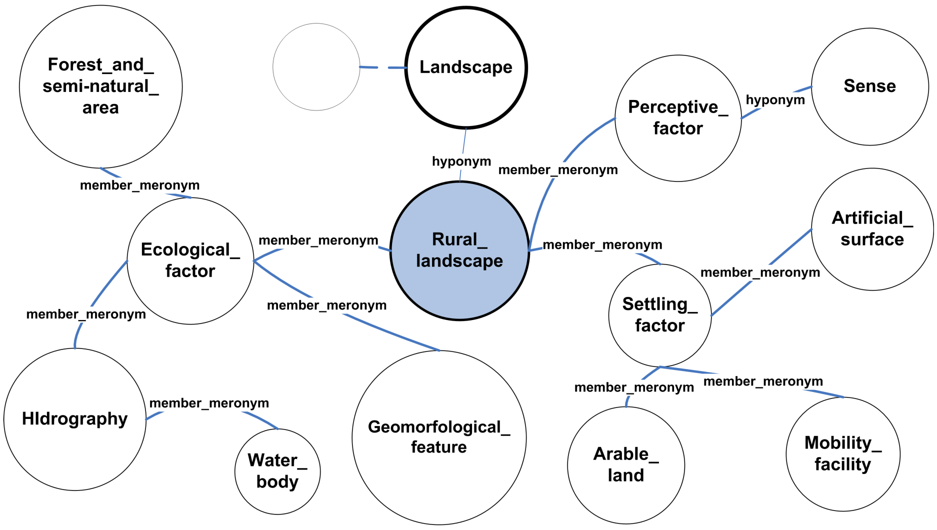

Figure 11. A portion of the Rural landscape Ontology Graph

Concept	Description	Reference
Rural landscape	The area outside the larger and moderate-sized cities and surrounding population concentrations. Generally characterized by farms, ranches, small towns, and unpopulated regions	[35]
Ecological factor	The study of animals and plants in relation to their environment. Human ecology deals with human communities in relation to their environment	[60]
Forest and semi-natural areas	A complex ecosystem in which trees are the dominant life-form	[27]
Hidrography	The measurement and description of the physical features and conditions of navigable waters and adjoining coastal areas, including oceans, rivers, and lakes	[46]
Water courses	A natural or artificial water-course serving as water drainage channel. Includes canals	[32]
Water body	A natural or artificial stretch of water	[32]
Geomorfological feature	The structural framework of landscape, weathering and soils, mass movement and hillslopes, fluvial features, eolian features, glacial and periglacial phenomena, coastlines, and karst landscapes	[46]
Historical settling factor	Colonization by agricultural workers and their families of virgin	[52]
Artificial surface	An Area of other than housing buildings, in-door spaces, stables, garages, workshops, lay-by and storing areas, often also bad land with ruderal vegetation, part of farms. The farms are often located in outskirts or close to rural settlements with agricultural function. Concentration of agricultural buildings in areas of various sizes was associated with collectivization of agriculture	[32]
Arable land	A lands under a rotation system used for annually harvested plants and fallow lands, which are permanently or not irrigated. Includes flooded crops such as rice fields and other inundated croplands	[32]
Mobility facility	Motorways and railways, including associated installations (stations, platforms, embankments)	[32]

Table 8: Rural Landscape Glossary

References

[1] COST UCE Action C21, Urban Ontologies for an improved communication in UCE projects - TOWNTOLOGY. COST (European Co-operation in the field of Scientific and Technical Research), http://www.towntology.net/,EU.

[2] AA.VV. *Proceedings IVth Global Congress on Heritage Interpretation*. Association for Heritage Interpretation, Barcelona, Spain, 1995.

[3] AA.VV. *Premier colloque international sur l'Interpretation du patrimoine. Actes du Colloque de Chateau d'Auvers*. Les Cahiers de l'Espace, Auvers-sur-Oise, France, 2000.

[4] AA.VV. *Historische Kulturlandschaft, landliche Entwicklung in Bayern, Materialen Heft 39/2001*. Bayerisches Staatsministerium fur Landwirtschaft und Forsten, Munchen, Germany, 2001.

[5] R. Al King, A. Hameurlain, and F. Morvan. Ontology-based data source localization in a structured peer-to-peer environment. In *IDEAS '08: Proceedings of the 2008 international symposium on Database engineering & applications*, pages 9–18, New York, NY, USA, 2008. ACM.

[6] M. Arumugam, A. P. Sheth, and I. B. Arpinar. Towards P2P semantic web: A distributed environment for sharing semantic knowledge on the web. In *Proceedings of the Workshop on Real World RDF and Semantic Web Applications*, 2002.

[7] R. Baeza-Yates and B. Ribeiro-Neto. *Modern Information Retrieval*. Addison Wesley, May 1999.

[8] T. Bandholtz. Sharing ontology by web services: Implementation of a semantic network service (sns) in the context of the german environmental information network (gein). In *Proceedings of SWDB'03*, pages 189–201, 2003.

[9] P. Becker, P. Eklund, and N. Roberts. Peer-to-peer based ontology editing. In *Proceedings of NWESP '05*, page 259, Washington, DC, USA, 2005. IEEE Computer Society.

[10] T. Berners-Lee, J. Hendler, and O. Lassila. The semantic web: A new form of web content that is meaningful to computers will unleash a revolution of new possibilities. *Scientific American*, 284(5):28–37, 5 2001.

[11] D. G. Bobrow and T. A. Winograd. An overview of krl, a knowledge representation language. Technical report, Stanford, CA, USA, 1976.

[12] M. Bonifacio, P. Bouquet, and P. Traverso. Enabling distributed knowledge management: Managerial and technological implications. *Novatica and Informatik/Informatique*, 3(1), 2002.

[13] R. J. Brachman. What's in a concept: Structural foundations for semantic nets. *International Journal of Man-Machine Studies*, 9(2):127–152, 1977.

[14] R. J. Brachman. On the epistemological status of semantic networks. In N. V. Findler, editor, *Associative Networks: Representation and Use of Knowledge by Computers*, pages 3–50. Academic Press, Orlando, 1979.

[15] R. J. Brachman and J. Schmolze. An overview of the kl-one knowledge representation system. *Cognitive Science*, 9(2):171–216, 1985.

[16] C. Tempich et al. Xarop: A midterm report in introducing a decentralized semantics-based knowledge sharing application. In *Proceedings of PAKM 2004*, Vienna, Austria, 2004. Springer.

[17] A. Calcagno Maniglio. Metodologia per la redazione di un atlante dei paesaggi italiani. In F. Mazzino and A. Ghersi, editors, *Per un atlante dei paesaggi italiani*. Alinea Editrice, Firenze, Italy, 2003.

[18] R. Cantoni. *Il pensiero dei primitivi*. Il Saggiatore, Milano, Italy, 1971.

[19] C. Carrier. Teora y practicas de la interpretacion. *Boletin del Instituto Andaluz del Patrimonio Histrico*, 6(25):140–147, 1998.

[20] Countryside Commission (CC). The Kent Downs Landscape: An assessment of the Area of Outstanding Natural Beauty, 1995.

[21] P. Daras, D. Tzovaras, S. Dobravec, J. Trnkoczy, A. Sanna, G. Paravati, R. Traphoener, J. Franz, T. Kastrinogiannis, C. Malavazos, N. Ploskas, M. Gumz, K. Geramani, and G.-J. Wintterle. Victory: a 3d search engine over p2p and wireless p2p networks. In *WICON '08: Proceedings of the 4th Annual International Conference on Wireless Internet*, pages 1–5, ICST, Brussels, Belgium, Belgium, 2008. ICST (Institute for Computer Sciences, Social-Informatics and Telecommunications Engineering).

[22] C. S. de las Heras. *Planificacion interpretativa y diseno de centros*. Consejera de Cultura, Sevilla, Spain, 2002.

[23] C. Doulkeridis, K. Någ, and M. Vazirgiannis. Peer-to-peer similarity search over widely distributed document collections. In *LSDS-IR '08: Proceeding of the 2008 ACM workshop on Large-Scale distributed systems for information retrieval*, pages 35–42, New York, NY, USA, 2008. ACM.

[24] E. Bozsak et al. Kaon – towards a large scale semantic web. In *Proceedings of EC-Web 2002*, volume 2455, pages 304–313. Springer, 2002.

[25] U. Eco. *La struttura assente. La ricerca semiotica e il metodo strumentale*. Bompiani, Milano, Italy, 1968.

[26] U. Eco. *Segno*. Isedi, Milano, Italy, 1974.

[27] Ecoles du Paysage. Atlas de paysage de Fontainebleau. In A. Freytet, editor, *Paysages de la foret de Fontainebleau. Ambiances, sites et motifs*. Enjeux et intentions paysagere, Office National des Forets, Direction Regionale de l'Environment d'Ile de France, Paris, France, 1996.

[28] R. Y. Edwards. Interpretation: What should it be? *Journal of Interpretation*, 1(1):9–12, 1976.

[29] P. Eklund, N. Roberts, and S. Green. Ontorama: Browsing rdf ontologies using a hyperbolic-style browser. In *Proceedings of CW '02*, page 0405, Washington, DC, USA, 2002. IEEE Computer Society.

[30] Encyclopaedia Britannica, editor. *Britannica Concise Encyclopedia*. Encyclopaedia Britannica, 2006.

[31] K. Erman. Witting techniques for interpreters. *Interpretation Canada*, 9(1):3–6, 1981.

[32] EU. The european council convention for the protection of the architectural heritage of europe. Granada, Spain, 1985.

[33] EU. The european convention on the protection of the archaeological heritage (revised). La Valletta, Malta, 1992.

[34] EU. The pan-european strategy of the biological and landscape diversity. Sofia, Bulgaria, 1992.

[35] EU. CORINE Land Use Project, 2000.

[36] EU. European landscape convention, 2000.

[37] M. S. Fox, J. M. Wright, and D. Adam. Experiences with srl: an analysis of frame-based knowledge representations. In *Proceedings from the first international workshop on Expert database systems*, pages 161–172, Redwood City, CA, USA, 1986. Benjamin-Cummings Publishing Co., Inc.

[38] J. P. Friedman, J. C. Harris, and J. B. Lindeman. *Dictionary of Real Estate Terms*. Barron's Educational Series, 6 edition, 2005.

[39] G. Xexeo et al. Peer-to-peer collaborative editing of ontologies. In *Proceedings of CSCWD '04*, pages 186–190, 2004.

[40] T. R. Gruber. A translation approach to portable ontology specifications. *Knowl. Acquis.*, 5(2):199–220, 1993.

[41] ICOMOS. The ICOMOS International Charter for the Conservation of Historic Towns and Urban Areas. Washington, USA, 1987.

[42] ICOMOS. ENAME: Interpretation and Presentation of Cultural Heritage Sites, 2007.

[43] V. Ingegnoli and S. Pignatti. *L'ecologia del paesaggio in Italia*. Città Studi Edizioni, Milano, Italy, 1996.

[44] Institut d'Amenagement et d'Urbanisme de la Region d'Ile de France. Ile de France. In J. Sgard, editor, *Le grand paysage d'Ile de France*. IAURIF, France, 1995.

[45] D. Jacobi. Le patrimoine, interpretation et mediation. In *Mediation culturelle dans un lieu patrimonial en relation avec son territoire*. Association pour l'Animation du Chateau de Kerjean, 2000.

[46] J. Le Goff. Documento/monumento. In *Enciclopedia*, volume 5. Enaudi, Torino, Italy, 1978.

[47] A. Leroi-Gourhan. *Le geste et la parole*, volume 2. Albin Michel, Paris, France, 1971.

[48] Marc Ehrig et al. Swap: Ontology-based knowledge management with peer-to-peer. In E. Izquierdo, editor, *Proceedings of WIAMIS'03*, pages 557–562, London, 2003. World Scientific.

[49] McGraw-Hill, editor. *Encyclopedia of Science and Technology*. The McGraw-Hill Companies, Inc., 2005.

[50] G. A. Miller. Wordnet: a lexical database for english. *Commun. ACM*, 38(11):39–41, 1995.

[51] M. Minsky. A framework for representing knowledge. Technical report, Cambridge, MA, USA, 1974.

[52] T. Miyazaki, T. Watanabe, A. Kanzaki, T. Hara, and S. Nishio. Keyword search considering user's preference in p2p networks. In *ICUIMC '09: Proceedings of the 3rd International Conference on Ubiquitous Information Management and Communication*, pages 432–440, New York, NY, USA, 2009. ACM.

[53] J. Morales. Los objetivos especficos de la interpretacion. Technical report, 2001.

[54] K. Nakayama, T. Hara, and S. Nishio. An agent system for ontology sharing on www. In *Proceedings of WWW '05*, pages 964–965, New York, NY, USA, 2005. ACM.

[55] R. Neches, R. Fikes, T. Finin, T. Gruber, R. Patil, T. Senator, and W. R. Swartout. Enabling technology for knowledge sharing. *AI Mag.*, 12(3):36–56, 1991.

[56] OECD-Organization for economic co-operation and development. Macrothesaurus. www.oecd.org, 2007.

[57] J. Padró. La interpretacion del patrimonio. contexto, situacion actual y tendencias de futuro. In *Proceedings of the III, IV y V Jornadas Andaluzas de Difusion*, pages 41–47. Junta de Andaluca, 2002.

[58] R. Palma, P. Haase, and A. Gómez-Pérez. Oyster: sharing and re-using ontologies in a peer-to-peer community. In *Proceedings of WWW '06*, pages 1009–1010, 2006.

[59] G. Pirrò, M. Ruffolo, and D. Talia. Advanced semantic search and retrieval in a collaborative peer-to-peer system. In *UPGRADE '08: Proceedings of the third international workshop on Use of P2P, grid and agents for the development of content networks*, pages 65–72, New York, NY, USA, 2008. ACM.

[60] L. S. Prakash, D. K. Saini, and N. S. Kutti. Integrating edulearn learning content management system (lcms) with cooperating learning object repositories (lors) in a peer to peer (p2p) architectural framework. *SIGSOFT Softw. Eng. Notes*, 34(3):1–7, 2009.

[61] Regione Valle d'Aosta. *Piano Territoriale Paesistico*. Aosta, Italy, 1996.

[62] E. Salzano. Il paesaggio è il prodotto storico della cultura e del lavoro dell'uomo sulla natura. Gazzetta Ambiente, 1999. Venezia, Italy.

[63] L. Scazzosi. *Reading the Landscape*. Gangemi, Roma, Italy, 2005.

[64] A. Schutz. *Reflections on the problem of relevance*. Yale University Press, New Haven, CT, USA, 1970.

[65] P. Sereno. Introduzione all'edizione italiana. La geografia storica in Italia. In A. Baker, editor, *Geografia storica: tendenze e prospettive*. Franco Angeli, Milano, Italy, 1981.

[66] D. Skoutas, V. Kantere, A. Simitsis, and T. Sellis. Ontology-based data sharing in p2p databases. pages 117–137, 2008.

[67] C. Soanes and A. Stevenson. *Oxford Dictionary of English*. Oxford university press, 2005.

[68] C. Socco. La polisemia del paesaggio. In P. Castelnovi, editor, *Il senso del paesaggio*. IRES, Turin, Italy, 1998.

[69] S. Staab and H. Stuckenschmidt. *Semantic Web and Peer-to-Peer - Decentralized Management and Exchange of Knowledge and Information*. Springer, 2006.

[70] F. Tilden. *Interpreting our heritage*. The University of Carolina Press, Chapel Hill, USA, 1977.

[71] E. Turri. La lettura del paesaggio. In M. C. Zerbi, editor, *Il paesaggio tra ricerca e progetto*. Giappichelli, Torino, Italy, 1994.

[72] UN. The quito meeting. Quito, Ecuador, 1977.

[73] UN. The convention on the biological diversity. Rio de Janeiro, Brazil, 1992.

[74] UN. The Charter of Krakow: Principles for Conservation and Restoration of Built Heritage. Krakow, Poland, 2000.

[75] UNESCO. The UNESCO Convention of the World Cultural and Natural Heritage Safeguard. Paris, France, 1972.

[76] UNESCO. The UNESCO Convention for the Safeguarding of the Intangible Cultural Heritage. Paris, France, 2003.

[77] UNESCO. The UNESCO Convention on the Protection and the Promotion of the Diversity of Cultural Expressions. Paris, France, 2005.

[78] Vromraad. De Schoonheid van het Plattland, vier essays over de kwaliteit van het Nederlandse Cultuurlandschap, 1999.

[79] E. Wenger and B. Snyder. Communities of practice: The organizational frontier. *Harvard Business Review*, 78(1):139–145, 2000.

[80] H. F. Witschel. Ranking information resources in peer-to-peer text retrieval: an experimental study. In *LSDS-IR '08: Proceeding of the 2008 ACM workshop on Large-Scale distributed systems for information retrieval*, pages 75–82, New York, NY, USA, 2008. ACM.

[81] W. A. Woods. What's in a link: Foundations for semantic networks. In D. G. Bobrow and A. Collins, editors, *Representation and Understanding*, pages 35–82. Academic Press, New York, 1975.

[82] D. Ye, Q. Bai, and M. Zhang. Ontology-based knowledge representation for a p2p multi-agent distributed intrusion detection system. *Network and Parallel Computing Workshops, IFIP International Conference on*, 0:111–118, 2008.

[83] Y. Zhang, Y. Qu, H. Huang, D. Yang, and H. Zhang. An ontology and peer-to-peer based data and service unified discovery system. *Expert Syst. Appl.*, 36(3):5436–5444, 2009.

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