Artificial Intelligence and Law (2007) 15:19–48
DOI 10.1007/s10506-007-9041-5

An Ontology for G2G Collaboration in Public Policy Making, Implementation and Evaluation

EURIPIDIS N. LOUKIS
Department of Information and Communication Systems Engineering, University of Aegean, Karlovassi, Island of Samos, 83200, Greece
E-mail: eloukis@aegean.gr

Abstract. This paper concerns the development and use of ontologies for electronically supporting and structuring the highest-level function of government: the design, implementation and evaluation of public policies for the big and complex problems that modern societies face. This critical government function usually necessitates extensive interaction and collaboration among many heterogeneous government organizations (G2G collaboration) with different backgrounds, mentalities, values, interests and expectations, so it can greatly benefit from the use of ontologies. In this direction initially an ontology of public policy making, implementation and evaluation is described, which has been developed as part of the project ICTE-PAN of the Information Society Technologies (IST) Programme of the European Commission, based on sound theoretical foundations mainly from the public policy analysis domain and contributions of experts from the public administrations of four European Union countries (Denmark, Germany, Greece and Italy). It is a 'horizontal' ontology that can be used for electronically supporting and structuring the whole lifecycle of a public policy in any vertical (thematic) area of government activity; it can also be combined with 'vertical' ontologies of the specific vertical (thematic) area of government activity we are dealing with. In this paper is also described the use of this ontology for electronically supporting and structuring the collaborative public policy making, implementation and evaluation through 'structured electronic forums', 'extended workflows', 'public policy stages with specific sub-ontologies', etc., and also for the semantic annotation, organization, indexing and integration of the contributions of the participants of these forums, which enable the development of advanced semantic web capabilities in this area.

Key words: G2G (Government-to-Government) e-Government, G2G (Government-to-Government) Collaboration, public policy, ontology, semantic web

1. Introduction

While the term ontology has been used for quite long time in the area of philosophy, meaning the research on 'the nature of being', it is only in the last 15 years that this term has been used in the area of Artificial Intelligence with a very different meaning, defined as a 'formal explicit specification of a shared conceptualization' (Gruber 1993). An ontology

constitutes an abstract conceptual model of a particular domain, which identifies the kinds of entities existing in this domain and the kinds of relations among them, and also is acceptable and shared by a group of people dealing with this domain (Fensel 2004; Visser and Bench-Capon 1998); in this sense, the ontology establishes a common vocabulary for the members of this group in order to create, exchange, combine, retrieve and reuse knowledge. According to Uschold and Grunninger, ontologies are of critical importance in the following five areas: development of domain-theory, knowledge acquisition, knowledge exchange, knowledge systems design and system documentation (Uschold and Grunninger 1996). Valente argues that the five main 'roles' of ontologies are for supporting and enhancing: (a) organizing and structuring information, (b) reasoning and problem solving, (c) semantic indexing and search, (d) semantic integration and interoperation and (e) understanding of the domain (Valente 2005). Recently, the wide adoption of the Internet made ontologies a key technology for supporting and enhancing the exchange of data and knowledge among human and software agents, the electronic commerce/business and the electronic collaboration. Ontologies constitute the key technology of the emerging semantic web (Antoniou and Van Harmelen 2004), which will be characterized by semantically annotated content that can be processed by computers, enabling new advanced services associated with more accurate search, filtering and categorization of information, higher automation of various tasks, better recommendations and decision support systems, etc.

For a given domain more than one ontologies can be created, each of them serving a different purpose and having a different perspective and/or level of detail. According to their perspectives ontologies can be classified into three categories (Visser and Bench-Capon 1998):

(i) Task ontologies: they define kinds of entities and relations that constitute a task-specific perspective of a domain (Chandrasekaran and Josephson 1997), e.g. an ontology of medical diagnosis tasks (its elements could be symptom, cause, etc.).
(ii) Method ontologies: they define kinds of entities and relations that constitute a method-specific perspective of a domain (Chandrasekaran and Josephson 1997), e.g. an ontology of the propose-and-revise method of design (its elements could be proposed solution, constraint, value assessment, etc.).
(iii) Domain ontologies: they define the kinds of entities and relations existing in a domain, e.g. an ontology for the legal domain (its elements could be norm, act, etc.).

The domain of government, being characterized by continuous and extensive collaboration among various stakeholders (e.g. various public

organizations of several administrative layers, associations and representatives of citizens and enterprises, etc.), usually with different backgrounds, mentalities, values, interests and expectations, can greatly benefit from ontologies. Ontologies can support and structure the required extensive government-to-government (G2G), government-to-businesses (G2B) and government-to-citizens (G2C) collaboration and improve its productivity and effectiveness.

The highest-level and most critical function of government is public policy making, implementation and evaluation. The development of effective public policies for the big and complex problems of modern societies is becoming more and more difficult and challenging. The social problems today tend to become more and more unclear, ill-defined, complex and unstructured; also, usually they are multi-dimensional (having multiple economic, social, environmental, educational, etc. dimensions), multi-stakeholder, and very often cross several regions or even countries (Nagel 1984; Rastogi 1992; Lynn 1996). Also the increasing globalization of the economy and international economic co-operation, beyond the benefits they generate, give rise to new complex problems of international nature. For the above reasons the development of effective public policies for most social problems requires close collaboration among many public organizations from several administrative layers, regions or even countries (e.g. central government organizations, regional administrations, prefectures, municipalities, local development organizations, employment organizations, social security organizations, educational organizations, environmental protection organizations, etc.), since usually there is no unique public organization possessing all the required competence, information and knowledge for managing the problem. Moreover, very often the participation of citizens and enterprises, or their associations/representatives, is required as well at least in some stages of the lifecycle of most public policies. The development of international organizations creates additional needs for collaboration among public organizations from several different countries, in order to design common public policies; for example, for the development of all policies and programmes of the European Union, after its enlargement, is required extensive collaboration among the involved public organizations from 25 member states. The implementation and the evaluation of public policies also have similar characteristics and require extensive collaboration among many stakeholders.

In all the above situations each stakeholder usually possesses one small piece of information, knowledge and competence about the problem. Very often there are also differences among the values, views, interests and expectations of the various stakeholders. Therefore, it is necessary to organize properly the synthesis of these valuable pieces of information, knowledge and competence, and also of the different values, interests and

expectations of the stakeholders, though close and effective collaboration among them. However, geographical distance in combination with time and budget limitations do not allow this collaboration to be close enough, often resulting in sub-optimal, ineffective and not acceptable public policies, which are developed without the required wide participation of all stakeholders (public organizations, citizens and enterprises associations/representatives, etc.). For these reasons it is of critical importance to exploit the capabilities of information and communication technologies (ICT) in order to support and facilitate the collaboration and synthesis required for public policy making, implementation and evaluation, by enabling a wide electronic participation and interaction of the numerous and geographically distributed stakeholders at a low cost. The development and use of ontologies can be of critical importance for supporting, structuring and enhancing this electronic interaction and collaboration.

In this direction this paper concerns the development and use of ontologies, a major and promising Artificial Intelligence (AI) technique, for supporting and structuring electronically this highest-level function of government: public policy making, implementation and evaluation, through supporting and structuring electronically the required interaction and collaboration among the involved public organizations. In this sense this paper also contributes to the area of 'strategic level' G2G (Government-to-Government) e-Government (with this term meaning G2G e-Government aiming to support strategic level functions of government). As described in more detail in the next section, even though many ontologies have been developed for the domain of government, limited research has been conducted on advanced uses of ontologies in e-Government (Tambouris et al. 2004); moreover, even this limited research is dealing with the use of ontologies for supporting and enhancing 'operational level' e-Government, mainly for enabling advanced electronic transactions of citizens and enterprises government agencies, e.g. for enabling advanced electronic 'one-stop shops'. However, there is a lack of research on advanced uses of ontologies for supporting 'strategic level' e-Government. In this direction, this paper initially describes an ontology of public policy making, implementation and evaluation, which can support and structure electronic G2G collaboration for these purposes; the proposed ontology can also be used for electronically supporting and structuring the participation of citizens, enterprises and their associations-representatives in public policy making and evaluation. The basic objective of this ontology is to facilitate and support the creation, organization, indexing, retrieval, reuse, exchange and combination of knowledge on social problems and public policies for managing them. It is a 'horizontal' ontology, which can be used for electronically supporting and enhancing the public policy process in any vertical (thematic) area of government

activity (e.g. environment, industry, agriculture, tourism, education, urban space management and planning, etc.); it can also be combined with 'vertical' ontologies of the specific vertical (thematic) area of government activity we are designing public policies for. Also, in this paper is described the use of this ontology for 'fulfilling' three of the five basic 'roles' of ontologies proposed by Valente (Valente 2005): for roles (a) (organize and structure information), (c) (semantic indexing and search) and (d) (semantic integration and interoperation). In this paper is also described the use of this ontology for electronically supporting and structuring the collaborative public policy making, implementation and evaluation through 'structured electronic forums', 'extended workflows', 'public policy stages with specific sub-ontologies', etc., and also for the semantic annotation, organization, indexing and integration of the contributions of the participants of these forums, which enable the development of advanced semantic web capabilities in this area.

It should be noted that the ontology and its uses described in this paper have been developed as part of the project ICTE-PAN (Methodologies and Tools for Building Intelligent Collaboration and Transaction Environments for Public Administration Networks) (http://www.eurodyn.com/icte-pan/) of the IST Programme of the European Commission (IST-2001-35120) (Loukis and Kokolakis 2003, 2004). The main objective of this project was to develop an electronic collaboration environment for supporting the various G2G collaboration typologies of modern public administration, with main emphasis on supporting collaborative public policies and programmes design, monitoring and evaluation. The above project has been implemented by a consortium of technology providers and public organizations-users, consisting of European Dynamics (Greece), University of the Aegean (Greece), TXT Solutions (Italy), National Environment Research Institute (Denmark), Ministry of Environment of Lower Saxony (Germany) and Province of Genoa (Italy).

The structure of the paper is as follows. In the following Section 2 there is a review of the existing government ontologies. In Section 3 is described the method we followed for developing the ontology and also its theoretical foundations coming mainly from the public policy analysis domain, while the ontology is presented in Section 4. The use of the ontology for supporting public policy making, implementation and evaluation and also its first level application are described in Section 5. Finally in Section 6 the conclusions are outlined and future research directions are proposed.

2. Government ontologies

As mentioned in the introduction, the government domain is characterized by high complexity (numerous public organizations of several administrative

layers with complex distribution of competencies and various kinds of hierarchical relations among them), and at the same time extensive interaction and collaboration, in which usually many stakeholders are involved, such as various public organizations, associations and representatives of citizens and enterprises, etc. For these reasons many ontologies have been created for the domain of government, in order to establish a 'common language' and facilitate this interaction and collaboration among the numerous stakeholders. Each of these ontologies serves a different purpose and has a different perspective. The existing government ontologies can be divided into two basic categories: vertical and horizontal government ontologies.

The 'vertical' government ontologies concern specific thematic areas of government activity. Some representative ones are discussed in the following paragraphs. One of the most important thematic areas of government activity environmental management; since environmental problems often cross the borders of cities, regions or even countries, environmental management necessitates close collaboration among many public organizations, either from the same or even from different countries (e.g. all the countries crossed by a river). For this reason the development and use of ontologies in this area is of critical importance. In this direction the European Union, as part of the CORINE (CO-oRdination of INformation on the Environment) Project, initially developed a multi-layered ontology-nomenclature of land cover terms, consisting of 44 classes of terms and their detailed definitions. (Lagouvardos 1999), in order to coordinate all the authorities of the member states involved in the production and use of environmental information. Later, in the same direction, the GEMET (General Multilingual Environmental Thesaurus) was developed as an indexing, retrieval and control tool for the European Topic Centre on Catalogue of Data Sources (ETC/CDS), the European Environment Agency (EEA) and the European Environmental Information and Observation Network (EIONET); it is a poly-hierarchical, poly-thematic and multilingual thesaurus of 6.562 environmental terms, which have been arranged in a classification scheme made of 3 super-groups, further decomposed into 35 groups, and 40 themes (http://www.eionet.eu.int/gemet). Also more specialized ontologies have been developed in this area, such as the WaWO (WasteWater Ontology), which aims at standardizing the terminology and facilitating communication and knowledge sharing in the domain of wastewater treatment (Ceccaroni et al. 2000; Ceccaroni 2004; Ceccaroni et al. 2004); it is an hierarchically-structured set of terms used in this area, categorized as Off-line Descriptors, On-line Descriptors or Calculated Descriptors, and the relations among them.

Another important and highly visible thematic area of government activity is urban space management and planning; since this activity is fragmented among many public organizations of several administrative

layers, ontologies have been developed in order to facilitate the collaboration and the exchange of data among them (Fonseca et al. 2000; Benslimane et al. 2000). These urban space ontologies comprise the main objects (e.g. legal and administrative regions, streets, blocks, parcels, schools, etc.), events (e.g. traffic accidents, maintenance actions, etc.) and relations (e.g. a parcel belongs to a block) that have to be dealt with in urban space management and planning. In the area of government statistics the GovStat Ontology has been developed in order to facilitate the efficient access to and use of US government statistical information by people with limited knowledge on statistics (Haas et al. 2003; Pattuelli et al. 2003). It includes the statistical terms that the users of the US federal statistical websites need to understand in order to find and use the information they seek. It also includes the relationships among these terms, which can be grouped into two categories: taxonomic relationships ('is-a' and 'part-whole' relationships), which express the hierarchy among the statistical concepts, and domain or functional relationships (such as 'is-described-by', 'is-an-estimate-of', 'synonym-of', etc.).

In the area of cultural heritage, in order to achieve integration of digital cultural information from various 'collective memory organizations', such as museums, archives, libraries, etc., the International Committee for Documentation of the International Counsil of Museums (CIDOC/ICOM) constructed a high-level ontology named Conceptual Reference Model (CRM) (Doerr 2003; Doerr et al. 2003); it consists of 80 classes and 130 properties arranged in multiple 'is-a hierarchies', and is expected to allow global search and comparative studies from the existing numerous heterogeneous sources of digital cultural information. Also, motivated by the need to improve the effectiveness of the continuously increasing government spending on digital libraries and research, the Scholarly Ontologies (SchlOnto) project develops an ontology for scholarly discourse. This ontology supports the interpretation and association of various types of research 'nodes' (i.e., research documents, conclusions, theories, models, etc.) and the argumentation on them (Buckingham et al. 2000; Buckingham et al. 2003; Uren et al. 2004). In particular, each node can be associated with another node (i.e., research document, conclusion, theory, model, etc.) via a 'claim'; as claim is defined a triple of one node or claim, a relation (the ontology defines various possible relations, such as 'supports', 'challenges', 'addresses', 'part of', etc.) and another node or claim. In this way extensive networks of claims and nodes can be created, which facilitate the efficient and intelligent retrieval of research documents from the numerous digital libraries, and also the evaluation of the contribution they make and the additional research required; in this way the effectiveness of the high government spending on digital libraries and research can significantly increase.

Smaller is number of the existing 'horizontal' government ontologies, which concern all the thematic areas of government activity. In particular, since one of the most important duties of government, in all its thematic areas of activity, is the production and enforcement of legislation, extensive research has been conducted on legal domain ontologies. An early attempt to conceptualize the legal domain is the ontology of McCarty's Language for Legal Discourse (McCarty 1989); its basic components are 'atomic formulae' (predicate relations used to express factual assertions), 'rules' (connections of atomic formulae with logical connectives) and 'modalities' (time, events, actions and deontic expressions). Stamper proposed the NORMA formalism for the representation of legal knowledge, which is based on an ontology, whose main concepts are 'agents' (organisms who gain knowledge, regulate and modify the world by means of actions), 'behavioural invariants' (features remaining invariant over some time) and 'realizations' (agents realize situations, which are denoted by behavioural invariants, by performing actions) (Stamper 1991, 1996). Valente created an ontology of law, which is based on a functional perspective of the legal system (Valente 1995; Breuker et al. 1997); this ontology views the legal system as an instrument to change or influence society in specific directions corresponding to widely acceptable social goals. This basic function can be decomposed into six primitive functions, which correspond to six categories of primitive legal knowledge: 'normative knowledge' (knowledge that defines a standard of social behaviour), 'world knowledge' (knowledge that describes the world being regulated), 'responsibility knowledge' (knowledge about assignment, extension or restriction of responsibilities of agents), 'reactive knowledge' (knowledge about reactions that should be taken if an action violates a norm), 'meta-legal knowledge' (knowledge about legal knowledge and system) and 'creative knowledge' (knowledge concerning the creation of previously non-existent legal entities). Van Kralingen and Visser studied methods for developing legal knowledge systems and concluded that legal domain ontologies are required in order to reduce the task-dependency of these systems; for this purpose they proceeded to the development of a legal domain ontology (Van Kralingen 1995; Visser 1995; Visser and Bench-Capon 1996a, b; Van Kralingen 1997; Van Kralingen et al. 1999). Their ontology is divided into two parts: the 'legal ontology', which includes generic components that can be reused in any legal sub-domain, and the 'statute-specific ontology', which includes components that concern specific legal sub-domains. The legal ontology defines three basic entities: 'norms' (general rules, standards and principles of behaviour that subjects of law have to comply with), 'acts' (dynamic aspects which effect changes in the state of the world) and 'concept descriptions' (meanings of the concepts found in the domain); for each of these three entities a frame structure is defined that lists all attributes relevant to the entity. The last two of the above ontologies are used for the devel-

opment of a method for 'translating' legislation and regulations into conceptual models in the project E-POWER under the IST Programme of the European Commission. These conceptual models are then used for the detection of various kinds of 'anomalies' of the legislation and the regulations (e.g. incompleteness, inconsistency, circularity, discrepancy, etc.), for simulation of their effects and for comparing and harmonizing legislation and regulations (e.g. across different countries); moreover, these models can be transformed into object models, which accelerate the development of the information systems required for the enforcement of legislation and regulations (Van Engers et al. 2000; Glassee et al. 2003; Boer et al. 2003). Also, ontologies for supporting efficient archiving, processing, management and retrieval of multimedia documents in criminal court trials have been developed as part of the projects CLIME (ESPRT Programme of the European Commission), e-COURT, and E-POWER (IST Programme of the European Commission); the basic ontology is a 'core/upper' ontology – called LRI – which provides 'anchors' to the major categories used in law (person, role, action, process, procedure, time, space, document, information, intention, etc.) and can be connected to various legal domain ontologies (Breuker 2002). These ontologies are used in tagging and annotating the documents of criminal court trials and then in searching and retrieving them.

Also, an interesting horizontal government ontology has been developed as part of the SMARTGOV project (IST Programme of the European Commission) for the domain of e-government transaction services (Adams et al. 2003; Fraser et al. 2003). This ontology includes the basic concepts of this domain (activities, actors, issues, legislation, needs, processes, requirements, responsibilities, results, rights and service types), which are common across all the thematic areas of government activity. It provides a 'shared vocabulary' for supporting the communication among the various categories of public organizations' staff involved in the development, deployment and maintenance of an e-government transaction service, e.g. managers, service designers, information systems developers, technical operation and support staff, administrative staff, etc.; also it supports knowledge management and sharing in this domain, by allowing 'knowledge units', which incorporate the existing experience about e-government transaction services, to be associated with the concepts and the relationships of this ontology.

However, from the above review of the existing government ontologies it has been concluded that there is lack of a horizontal ontology of the most important government function: public policy making, implementation and evaluation; in particular, is missing an ontology of the whole lifecycle of public policy, with the fundamental public policy concepts (kinds of elements) and the relations among them, which are used in public policy making, implementation and evaluation across all thematic areas of government activity. Such a horizontal ontology of public

policy would be quite useful, as it can increase the effectiveness of public policy design, implementation and evaluation, especially if it is used in combination with an appropriate vertical (thematic) ontology; also it can make the public policy process less 'thematic area-specific', and facilitate the coordination and the exchange of knowledge among different thematic areas of government activity. For these reasons both the 'physical' and the electronic collaboration for public policy design, implementation and evaluation can be significantly supported and enhanced by a horizontal ontology of public policy. Moreover, from our literature review it is concluded that, even though many government ontologies have been developed, limited research has been conducted on their exploitation in the context of e-Government (Tambouris et al. 2004). There are only a few projects focussing on the exploitation of ontologies for supporting and enhancing 'operational level' e-Government, such as the abovementioned projects SMARTGOV, e-POWER and e-COURT. Also, in this direction is the ONTOGOV project, which aims to develop, test and validate an ontology-enabled and semantically-enriched platform that facilitates the consistent composition, re-configuration and evolution of advanced electronic government transactions services (Tambouris et al. 2004). However, there is a lack of research on advanced uses of ontologies for supporting 'strategic level' e-Government, e.g. for the electronic ontology-enabled support and enhancement of public policy making, implementation and evaluation.

3. Ontology development method and theoretical foundations

According to Holsapple and Joshi (2002) there are five basic approaches to ontology development: inspirational (based on the viewpoint of an individual about the domain), inductive (based on the analysis of a small number of specific cases within the domain), deductive (based on some general principles about the domain), synthetic (based on synthesis from existing ontologies, with possible modifications and or expansions of them) and collaborative (based on the viewpoints of multiple individuals about the domain, possibly starting with an initial ontology produced using another approach, and then iterative improvement until consensus is reached); among these approaches the authors of the above paper advocate the collaborative approach, as it can result in more acceptable and complete ontologies, which incorporate many different viewpoints. Also in the same paper it is proposed that the practical implementation of this collaborative approach should be divided into the following four phases:

(I) Preparation (definition of ontology scope and design criteria)
(II) Anchoring (design of an initial ontology that will be used as a starting point of an iterative collaboration)

(III) Iterative improvement (various iterations of collecting views and critiques on the ontology from a panel of experts, revising–improving the ontology and producing new versions of it)
(IV) Application (initial applications of the ontology for several different purposes)

For the development of the ontology of public policy, which is presented in this paper, we adopted the collaborative-iterative approach, based on sound theoretical foundations from the public policy analysis domain and on the knowledge of experts in public policy design, implementation and evaluation from the public administrations of the four European Union countries that participated in the ICTE-PAN project (Denmark, Germany, Greece and Italy). In particular, for the development of this ontology the following steps have been undertaken:

(A) Initially the purpose and the scope of the ontology were discussed, clarified and finally agreed among all the partners of the ICTE-PAN project in a number of project meetings. It was agreed that the ontology should consist of the basic concepts used in the processes and practices of the whole lifecycle of public policy and the relations among them. Also it was agreed that this ontology would be incorporated in the 'structured forum' module of the G2G electronic collaboration environment under development in the project; the objective of this module was to support 'structured electronic consultations', where the participants can enter only some predefined kinds of elements, which can be associated only with some predefined kinds of relations.
(B) Then a first version of this ontology of public policy was produced, in order to be used as a starting point of an iterative collaborative improvement in the next step. It was based on theoretical foundations from the domain of public policy analysis (Nagel 1984; Rastogi 1992; Denhardt and Hammond 1992; Patton and Sawicki 1993; Lynn 1996; Walters and Sudweeks 1996), which has been characterized by big growth since the early 1970s, mainly due to the need of addressing the pressing social problems and needs, and improving the effectiveness of (=social value from) the high and continuously increasing government spending. The basic subjects of this domain are the goals of public policy and the means for achieving them, with main emphasis on the identification and evaluation (both ex-ante and ex-post) of policies and programmes in order to lessen or resolve the social problems. According to Patton and Sawicki (1993) public policy analysis can be 'prospective' (taking place before the implementation of public policies in order to predict the future states that will result from them, or recommend the most appropriate government actions for

achieving pre-defined goals) or 'descriptive' (taking place after the implementation of public policies in order to examine their effect, or evaluate whether their goals have been met). In the literature of this domain it is emphasized that the main challenges it faces come from the inherent characteristics of most social problems: usually they are not well-defined, they have multiple technical and political dimensions, and the solutions proposed for them do not guarantee the achievement of the intended results and cannot be proved to be correct before their application. For these reasons public policy analysis has to be based both on statistical information and appropriate analysis of it, and also on 'soft information', this term denoting many required pieces of knowledge, subjective images, world-views and meanings from many stakeholders (e.g. various public organizations, interest groups of citizens and enterprises, etc.). In order to meet these challenges various public policy analysis frameworks have been proposed in the relevant literature, most of them combining a 'rational model' with incorporation of values (e.g. of society in general, and/or of the main stakeholders of each particular policy). According to Walters and Sudweeks (1996) the main trend in this domain is a move from public policy analysis approaches with theoretical foundations from the domain of micro-economics, to new approaches with other theoretical foundations, which emphasize the importance of values in public policy, such as the 'socio-economics', the 'pragmatic liberalism', the 'public ideas' and the 'policy discourse'.

In this direction the four basic theoretical foundations of the first version of the ontology are:

(i) the public policy analysis framework proposed by Patton and Sawicki (1993), which combines a rational model with incorporation of society and stakeholders values, and includes the following six stages: define the problem, determine evaluation criteria, identify alternative policies, evaluate alternative policies, select the preferred policy and implement the preferred policy,

(ii) the 'policy life-cycle' model proposed by OECD (OECD 2003), which includes five basic stages of policy-making: agenda-setting, analysis, policy creation, implementation and monitoring,

(iii) the abovementioned 'policy discourse approach' (Fisher and Forrester 1993; White 1994; Walters and Sudweeks 1996); at the heart of this approach lies the premise that for the formation of public policies facts and values should be considered together in order to define both ends and means; taking into account that very often different stakeholders (e.g. different public organizations, interest groups of citizens and enterprises, etc., interested in or affected by the particular public policy)

have different values, the best approach is to establish an atmosphere of 'cooperative inquiry' based on a well-organized argumentation,

(iv) existing argumentation systems, such as the gIBIS (Conklin and Begeman 1988, 1989; Conklin 2003) and the HERMES (Karacapilidis 2000).

The first version of this ontology was also based on knowledge of experts: the four public organization/user partners of the project conducted interviews with staff from their national public administrations, who are experts in the design, implementation and evaluation public policy, concerning the processes and practices followed in the public policy cycle. Especially in Greece, several interviews were conducted with staff of the Ministry of National Economy, who are dealing with the operational and regional programmes of the Community Support Frameworks for Greece (http://www.3kps.gr/index_en.htm), concerning the processes and practices followed in these programmes (for the design of the basic public policy directions of these programmes, then for their analysis up to the level of measures and projects, their implementation and monitoring, and finally for their evaluation). From these interviews it was concluded that the ontology needed one additional theoretical foundation:

(v) the SWOT (Strengths – Weaknesses – Opportunities – Threats) analysis framework from the domain of strategic management (Johnson and Scholes 2002), which is increasingly used for the design of public policies for the development of regions or industries.

(C) Several iterations of review, critique and revision–improvement of this ontology were conducted. In the first iterations, which were conducted in the ICTE-PAN project meetings, participated representatives of the four public organization/user partners of the project; based on their remarks and critiques new versions of the ontology were produced. In next two iterations, which were conducted as part of the two ICTE-PAN project workshops, participated representatives from the public administrations of Denmark and Germany respectively; based on their remarks the current version of the ontology was produced.

(D) The ontology was incorporated in the 'structured forum' module of the G2G electronic collaboration environment that has been developed in this project, and was then used in the four pilot applications implemented as part of the project, as described in Section 5.

4. Description of the ontology

The concepts – kinds of elements of this ontology of public policy making, implementation and evaluation, and also kinds of relations among them, are

shown in Figure 1, using the IDEF5 notation (Perakath et al. 1994): the kinds of elements are represented as circles while the kinds of relations are represented as arrows. In the remaining of this section the kinds of elements and relations of the ontology (shown in capital letters) are described in detail.

The basic kind of elements dealt with in public policy analysis is the ISSUEs; a decision to be made, a goal to be achieved, a problem to be solved, a question to be answered, a concern or a basic requirement can be an ISSUE, e.g. to select the best location for the high school of a specific area, or to reduce the unemployment in a region, etc., ISSUEs. An ISSUE can GENERALIZE, SPECIALIZE, or QUESTION_REPLACE another ISSUE. Important SUBKINDs of ISSUEs, are the CAUSEs of the social problems and also their SYMPTOMs; a SYMPTOM can be DUE TO a CAUSE. Other important SUBKINDs of ISSUEs, which are used in Strategic SWOT (Strengths, Weaknesses, Opportunities and Threats) Analysis (e.g. geographical region, public organizations etc.), which is often carried

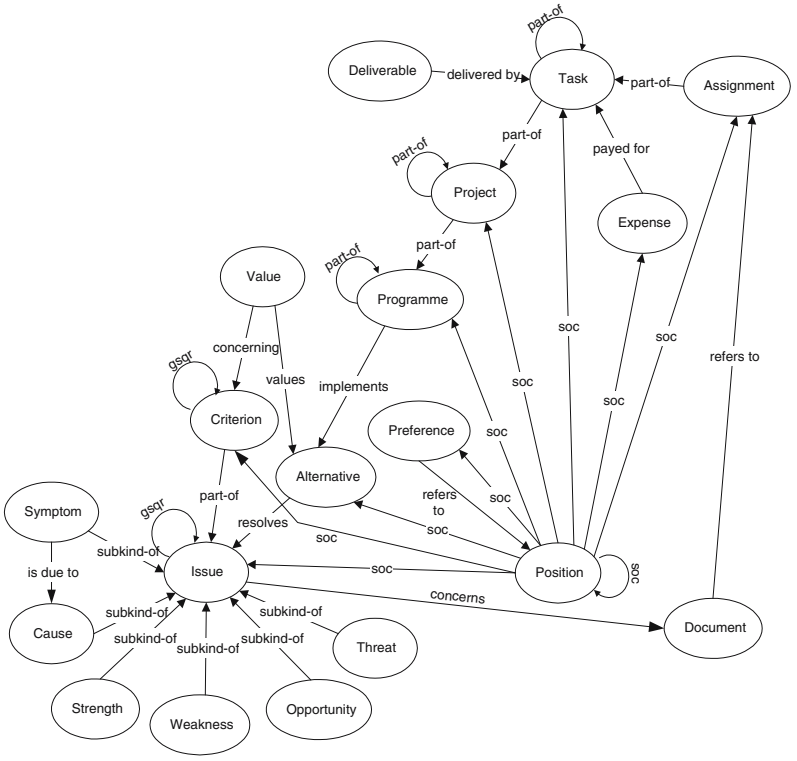

Figure 1. Ontology of public policy making, implementation and evaluation. gsqr = generalize, specialize, question-replace, soc = supports, objects-to, comments-on.

out before developing public policies and programmes, are the STRENGTHs, WEAKNESSes, OPPORTUNITYs and THREATs.

Another important kind of elements dealt with in public policy analysis is the ALTERNATIVEs; they are associated with ISSUEs. For every ISSUE, the appropriate ALTERNATIVEs should be found, which are general ways or broad directions of action, that can RESOLVE the ISSUE (e.g. solve the problem, or achieve the goal, or fulfil/satisfy the requirement). In the first example mentioned in the previous paragraph, ALTERNATIVEs could be city A, city B and city C, while in the second example ALTERNATIVEs could be to give financial incentives for investing in the area, to build infrastructure, to organize training programmes, etc.

These ALTERNATIVEs are discussed among the stakeholders; each of them can express on any of the ALTERNATIVEs one or more POSITIONs. A POSITION can be either a positive one that SUPPORTs an ALTERNATIVE, or a negative one that OBJECTS-TO an ALTERNATIVE, or even a neutral one that COMMENTS-ON an ALTERNATIVE. In the first of the above examples, POSITIONs on the first ALTERNATIVE (city A) could be various arguments in favour of or against building the high school in city A, or even just comments on it. Also a POSITION can be expressed on any other POSITION, which has been expressed by another stakeholder, etc. Moreover, very often POSITIONs are expressed on the ISSUEs themselves (positive positions = arguments – reasons for accepting the ISSUE itself, negative positions = arguments – reasons for not accepting the ISSUE itself, or comments on it).

All these expressed POSITIONs are not of equal importance; therefore stakeholders express their priorities/preferences concerning these POSITIONs; this is done via the kind PREFERENCEs. A PREFERENCE concerns via the relation REFERS_TO a pair of expressed POSITIONs (p1, p2), and has the form [p1, preference operator, p2], where the preference operator can take values 'more important'(>), 'less important'(<), or 'equally important'(=). In the above example a PREFERENCE could be expressed by a stakeholder, who believes that an advantage expressed for city A is more important than another advantage expressed for city B. These PREFERENCEs can also discussed by the stakeholders, therefore POSITIONs (positive, negative or just comments) can be expressed on them.

After this discussion, in which ISSUEs, ALTERNATIVEs, POSITIONs and PREFERENCEs are expressed by the stakeholders, very often a more structured multicriteria evaluation of the ALTERNATIVEs follows. Therefore, another important kind of elements in our ontology is evaluation CRITERIONs. Evaluation CRITERIONs in some cases are defined by law or past experience; however in some other cases they are defined by the stakeholders. In these cases in order to define for each ISSUE the appropriate CRITERIA for evaluating the corresponding ALTERNATIVEs, we can

follow a similar procedure to the one follow for defining the ALTERNATIVEs for the ISSUE. In the first of the above examples, CRITERIONs for evaluating the proposed cities for building the high school would be 'distances from the main cities and villages of the region', 'streets infrastructure', 'already existing school buildings infrastructure', etc. Similarly to the ISSUEs, a CRITERION can GENERALIZE, SPECIALIZE or QUESTION_REPLACE another CRITERION. These CRITERIONs are finalized and then used in the multicriteria evaluation of the ALTERNATIVEs proposed for this ISSUE; stakeholders assign VALUEs (ratings) to these ALTERNATIVE regarding the CRITERIONs. It should be noted that the above kinds of elements and relations can be used both for the design and for the evaluation of public policies, while the ones described in the following paragraph concern the implementation of public policies.

Finally from the above multicriteria evaluation one or more ALTERNATIVEs are selected, which are then elaborated and analyzed into various levels of PROGRAMMEs (e.g. programmes, subprogrammes, measures, etc.); so a PROGRAMME can directly IMPLEMENT an ALTERNATIVE, being a first level PROGRAMME, or can be PART_OF another PROGRAMME, being a lower level PROGRAMME, e.g. a subprogramme, measure, etc. Similarly each of the lowest level PROGRAMMEs is analyzed into PROJECTs, and again we can have PROJECTs of various levels (e.g. projects, subprojects, etc.). Each of the lowest level PROJECTs is then analyzed into TASKs, and we can also have TASKs of various levels (e.g. tasks, subtasks, etc.); finally for each TASK a number of DELIVERABLEs are defined, and also EXPENSEs and work ASSIGNMENTs are made. These PROGRAMMEs, PROJECTs, TASKs, EXPENSEs and ASSIGNMENTs can be discussed, so POSITIONs (positive, negative or just comments) can be expressed on them as well. Also for each work ASSIGNMENT usually some DOCUMENTs are produced, such as progress reports, etc., for which ISSUEs can be raised.

5. Use of the ontology

The ontology of public policy presented in the previous section was incorporated in the 'structured forum' module of the G2G electronic collaboration environment developed in the ICTE-PAN project (Loukis and Kokolakis 2003, 2004). It should be noted that this electronic collaboration environment has also a basic 'forum' module, which offers the capability to create and manage an electronic consultation on a topic; as we can see in Figure 2, in the window of such an electronic consultation each participant can enter 'positions' (e.g. views, opinions, etc.) on the topic of the consultation, read the positions entered by the other participants on the same topic, then on each of these positions enter

new positions, etc. (multi-thread electronic discussion). In this way a discussion tree is gradually created, similar to the one shown in Figure 2, consisting of interconnected positions of the participants on this topic.

However, from the requirements analysis conducted in this project it was concluded that a higher level of organization, structure and focus is necessary in electronic public policy consultations, especially if the topic is highly specialized and complex, and the participants are heterogeneous (e.g. of different background, mentality, etc.). For this reason it was decided that the G2G electronic collaboration environment should also have, beyond the above basic 'forum' module, an additional 'structured forum' module (Karacapilidis et al. 2004). This module offers the capability to create and manage a 'structured electronic consultation', where the participants can enter only some predefined kinds of elements from the ontology described in the previous section; also these predefined kinds of element can be associated only with some predefined relations from this ontology. In this way a higher level of consultation structure and focus can be achieved, which is necessary for having an effective and productive professional G2G collaboration on public policy; using an unstructured 'forum' instead would result in a much less productive interaction. In particular, in this 'structured forum' module in order to create a new structured electronic consultation we have to define a subset of the kinds of elements and relations of the ontology that will be allowed to the participants of this consultation; in this way the participants will be allowed to enter only these predefined kinds of elements, and also only these predefined relations will be allowed among them. These predefined kinds of elements and relations will constitute the 'ontology' of this structured electronic consultation, being in general a 'sub-ontology' of the ontology described in the previous section. For example in a structured electronic consultation about a specific public policy topic we can define that the participants:

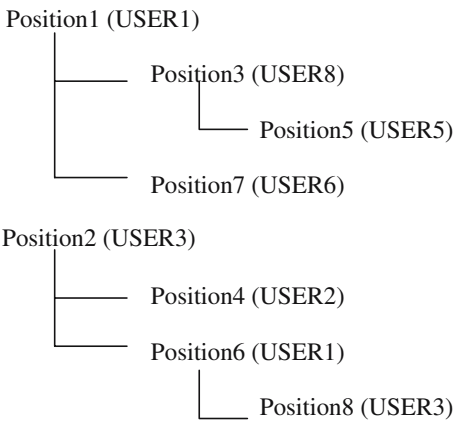

Figure 2. Discussion tree in the consultation widow of the 'forum' module.

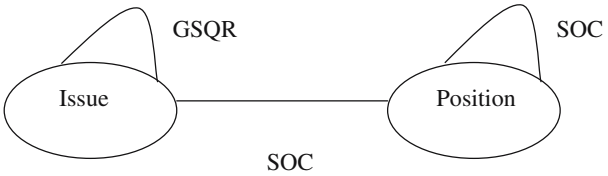

Figure 3. (Sub)Ontology of the structured electronic consultation.

– will be allowed to enter ISSUEs and POSITIONs,
– an ISSUEs will be allowed to be either independent or to GENERALIZE, SPECIALIZE, or QUESTION_REPLACE (GSQR) another ISSUE,
– and a POSITIONs will be allowed to SUPPORT, OBJECT-TO or COMMENTS-ON (SOC) an ISSUE or another POSITION.

The (sub)ontology of this structured electronic consultation is shown in Figure 3, while the discussion tree that will be gradually created from it will be similar to the one shown in Figure 4.

However, usually it is not practically possible and productive all the kinds of elements and relations of the ontology described in the previous section, namely the whole public policy lifecycle, to be dealt with in the same electronic consultation and by the same participants. Therefore it is necessary to define a number of stages – electronic consultations, each of them focussing on a specific subset of the kinds of elements and relations of the ontology (i.e., on a specific sub-ontology), which corresponds to a specific part of the public policy lifecycle, so that a higher level of focus and effectiveness can be achieved, and possibly engaging different participants. Each of these stages – electronic consultations has as input the output of the previous ones and its output will be used by the next ones, so they all constitute an 'extended public policy workflow', which in general can include several structured electronic consultations (sequentially and/or in parallel), and between them also several 'single person activities' (i.e., the typical atomic activities usually included in the 'traditional' workflows). For example the design of public policy for the

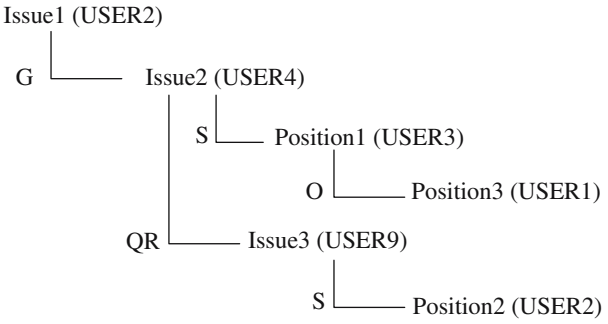

Figure 4. Discussion tree in the structured electronic consultation.

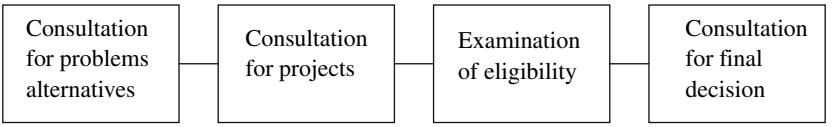

Figure 5. Extended workflow for the design of public policy for the development of a geographic region.

development of a geographic region, as we can see in Figure 5, can include a first structured electronic consultation for identifying the main problems of the region and defining alternative courses of action for addressing these problems; then a second structured electronic consultation for analysing these alternatives into specific projects; next some typical single person steps can follow in the Ministry of National Economy, in order to examine whether the proposed projects are eligible for financial support based on existing regulations; finally one more structured electronic consultation can take place, in order to make the final decision concerning the projects that will be supported, taking into account the results from the Ministry of National Economy. For each of the above three structured electronic consultations an appropriate sub-ontology should be defined.

In this way the concept of 'workflow' is extended so that it can include both single person activities and collaborative (consultation type) activities. The electronic collaboration environment that has been developed in the ICTE-PAN project can support such 'extended workflows', by offering the capability to incorporate an electronic consultation in a workflow as one of its activities (together with other electronic consultations and also single person activities). Through such a set of ontology-enabled structured electronic consultations all the required 'soft information' (according to the terminology of Section 3) for a public policy (i.e., numerous pieces of information, knowledge, views and values from all stakeholders) can be collected and synthesized; in this way can be electronically supported the G2G collaboration for public policy making, implementation and evaluation, and also the participation of interest groups of citizens and enterprises.

The number of the stages, their sub-ontologies (i.e., the kinds of elements and relations that will be dealt with in each stage), and in general the structure of the whole extended public policy workflow, should be decided based on the specific characteristics of each public policy situation or task; then based on this decision the above G2G electronic collaboration environment should be configured appropriately. A typical analysis of the whole public policy cycle into eight stages has been formulated, based on the public policy processes and practices followed by the examined public administrations, in order to be used as a guideline for making this decision concerning the structure of the public policy workflow. Each of these stages has a specific objective and a corresponding sub-ontology, i.e., it deals with a specific

subset of the kinds of elements and relations of the ontology. These eight typical public policy stages are:

I. Problem/goal understanding
II. Strategic analysis
III. Alternatives generation and evaluation
IV. Evaluation criteria generation
V. Structured multi-criteria evaluation of alternatives
VI. Design of programmes
VII. Design of projects
VIII. Project monitoring

For each of these eight typical public policy stages in the Appendix is given a short description and also its sub-ontology, i.e., the corresponding kinds of elements and relations it deals with.

Moreover, the public policy ontology described in Section 4 can be used for the semantic annotation of the contributions (postings) of the participants in a public policy structured electronic consultation, so that one structured XML file can be produced from each consultation; in this way, after a significant number of such public policy structured electronic consultations have taken place with participants from many public organizations, a big number of files of this type will have been produced, which will incorporate valuable knowledge about social problems and needs and public policies for addressing them. The ontology enables the development of various advanced capabilities concerning the efficient organization, retrieval, exchange and exploitation of the valuable knowledge incorporated in these files, such as:

– semantic organization and indexing
– semantic search, retrieval and visualization (e.g. of alternative solutions to a specific social problem, and also of their advantages and disadvantages, or criteria for evaluating them)
– semantic integration (e.g. combination of knowledge elements from several files corresponding to different structured electronic consultations with different participants)

In general, the proposed ontology enables the development of advanced semantic web capabilities (Antoniou and Van Harmelen 2004) in the area of public policy. These capabilities can be further enhanced if this 'horizontal' ontology is combined with a 'vertical' ontology of the specific vertical (thematic) area of government activity we are dealing with. One way of achieving such a combination would be to use within the various kinds of elements of this ontology (e.g. within the issues, alternatives, positions, programmes, projects, etc.) elements or controlled vocabularies from the vertical ontology. For example, for supporting the design, implementation and evaluation of public policies for the environment we can use this ontology, in combination

with a vertical ontology of the environment domain: in all relevant structured electronic consultations their participants for the descriptions of issues, alternatives, positions, programmes, projects, etc. concerning environmental problems can use elements or controlled vocabularies from environmental ontologies (e.g. from the GEMET ontology, mentioned in Section 2).

A first level evaluation of the ontology has been made in four pilot applications, which all concerned support of G2G collaboration using the above electronic collaboration environment developed in the ICTE-PAN project:

A. Quality assurance of the German Environmental Data Catalogue (Ministry of Environment of Lower Saxony, Germany)
B. Tendering and contracts (Province of Genoa, Italy)
C. Documents Review of the European Environment Information and Observation Network (National Environment Research Institute, Denmark)
D. Career Offices Network (University of the Aegean, Greece)

In all these four pilot applications the ontology was used, as part of the structured forum module, in order to structure electronic consultations. The evaluation of the ontology was positive, as the participants found that it was characterized by completeness and clarity, and also that it was very useful in structuring and focussing the electronic consultations. Also in the two ICTE-PAN project workshops mentioned in Section 3, in which representatives from the public administrations of Denmark and Germany participated, the overall comments on the ontology were positive. Therefore the conclusions from this first level evaluation of the ontology were encouraging. As a next step we are going to proceed to a more systematic evaluation of the ontology using existing ontology evaluation methodologies (Gomez-Perez 2001; Corcho et al. 2004; Lozano-Tello and Gomez-Perez 2004; Hartmann et al. 2005), such as the ODEVAL (it performs syntactic evaluation of RDF(S), DAML + OIL and OWL ontologies, and also evaluates their concept taxonomies from the point of view of knowledge representation based on graph theory), the ONTOMETRIC (it evaluates the suitability of an ontology for a particular system/use, based on Analytic Hierarchy Process (AHP) – a multicriteria decision analysis method – and taking into account five group of evaluation criteria), etc.

6. Conclusions

In the previous sections of this paper has been described the development and use of ontologies for electronically supporting and structuring the highest-

level function of government: the design, implementation and evaluation of public policies for the big and complex problems that modern societies face. Initially an 'horizontal' ontology of public policy making, implementation and evaluation has been presented, which can be used for electronically structuring and enhancing the whole lifecycle of public policy in any vertical (thematic) area of government activity; it can also be combined with vertical ontologies of the specific vertical (thematic) area of government activity it is used for. This ontology has been developed as part of the ICTE-PAN project of the IST Programme of the European Commission following a collaborative-iterative approach, based on sound theoretical foundations, mainly from the public policy analysis domain, and also on the experience of public policy experts from the public administrations of four European Union countries (Denmark, Germany, Greece and Italy). This ontology has been incorporated in the 'structured forum' module of the G2G electronic collaboration environment that has been developed in the above project, in order to structure the electronic consultations on public policy and semantically annotate the contributions (postings) of their participants. The results of a first level evaluation of the ontology concerning were encouraging.

In this paper we have also described how this ontology can be used for providing effective support and structure of public policy making, implementation and evaluation. It has been concluded that usually it is not practically possible and productive all the kinds of elements and relations of the ontology, namely the whole public policy lifecycle, to be dealt with in the same electronic consultation, so it is necessary to divide it into an number of stages – electronic consultations; each of them focusses on a specific subset of the kinds of elements and relations of the ontology (i.e., on a specific 'sub-ontology'), which corresponds to a specific part of the public policy lifecycle; in this way a higher level of focus and effectiveness can be achieved. In general, it is necessary for the specific public policy task we are dealing with to design an appropriate 'extended public policy workflow', which can include several structured electronic consultations (with different 'sub-ontologies'), and between them also several 'single person activities' (i.e., the typical atomic activities usually included in the 'traditional' workflows). A typical analysis of the whole public policy cycle into eight stages with specific sub-ontologies has been formulated, based on the public policy processes and practices followed by the examined public administrations, in order to be used as a guideline for the design of 'extended public policy workflows' for specific public policy tasks.

The proposed ontology can be used for the semantic annotation, organization, indexing, search, retrieval, exchange, visualization and integration of the valuable knowledge possessed by public organizations about various social problems and public policies for addressing them; this knowledge constitutes one of the most valuable and critical assets of public

organizations, which is usually not recorded (tacit knowledge) and therefore is under-exploited. In general this ontology enables the development of advanced semantic web capabilities in the area of public policy making, implementation and evaluation. From a knowledge management perspective (Nonaka and Takeuchi 1995) the proposed ontology can greatly support and facilitate the 'externalization' of knowledge on social problems and public policies for addressing them (i.e., conversion of tacit knowledge into explicit knowledge), and in general the whole knowledge management cycle (capture-refine-store-manage-disseminate) in this area.

As future research directions are proposed:

- Use and evaluation of the ontology in more cases of public policy design, implementation and evaluation.
- Systematic evaluation of the ontology using one of the existing ontology evaluation methodologies
- Combination of the ontology with vertical (thematic) ontologies of specific thematic areas of government activity.

Appendix: Typical stages of the public policy lifecycle

As mentioned in Section 5, an analysis of the public policy lifecycle has been formulated into eight typical stages. For each of them in this Appendix we describe its objective and also the corresponding subset of the kinds of elements and relations of the ontology the stage is dealing with.

PROBLEM/GOAL UNDERSTANDING

The objective of this stage is to understand better a social problem/goal, by collaboratively elucidating its main dimensions and components, their main characteristics, and also the associations among them.

The kinds of elements used in this stage are:

ISSUEs, or SYMPTOMs and CAUSEs, POSITIONs, PREFERENCEs,

while the kinds of relations are:

- GENERALIZE, SPECIALIZE, or QUESTION_REPLACE (between ISSUEs, between SYMPTOMs, between CAUSEs),
- IS_DUE TO (between SYMPTOMs and CAUSEs),
- SUPPORTS, OBJECTS, COMMENTS (between POSITIONs on one side and ISSUEs, PREFERENCEs or POSITIONS on the other),
- REFERS_TO (between PREFERENCEs and POSITIONs).

STRATEGIC ANALYSIS

The objective of this stage is to conduct collaboratively a Strategic SWOT (Strengths, Weaknesses, Opportunities and Threats) Analysis (e.g. of a specific geographic region, a national industry or a public organization etc.).

The kinds of elements used in this stage are:
STRENGTHs, WEAKNESSes, OPPORTUNITYs, THREATs, POSITIONs, PREFERENCEs,
while the kinds of relations are:
- GENERALIZE, SPECIALIZE, or QUESTION_REPLACE (between STRENGTHs, between WEAKNESSes, between OPPORTUNITYs, between THREATs),
- SUPPORTS, OBJECTS, COMMENTS (between POSITIONs on one side and STRENGTHs, WEAKNESSes, OPPORTUNITYs, THREATs, PREFERENCEs or POSITIONS on the other),
- REFERS_TO (between PREFERENCEs and POSITIONs).

ALTERNATIVES GENERATION AND EVALUATION

The objective of this stage is to collaboratively generate and propose alternative actions for an issue, and also to proceed to a first elaboration and evaluation of them, by expressing positive or negative positions on them.

The kinds of elements used in this stage are:
ISSUEs, ALTERNATIVEs, POSITIONs, PREFERENCEs,
while the kinds of relations are:
- RESOLVEs (between ALTERNATIVEs and ISSUEs),
- SUPPORTS, OBJECTS, COMMENTS (between POSITIONs on one side and ALTERNATIVEs, POSITIONs or PREFERENCEs on the other),
- REFERS_TO (between PREFERENCEs and POSITIONs).

EVALUATION CRITERIA GENERATION

The objective of this stage is to collaboratively generate and propose criteria for evaluating the alternative actions, which have been proposed for an issue, and also to proceed to a first elaboration and evaluation of these criteria, via positive or negative positions (in favour or against them respectively).

The kinds of elements used in this stage are:
ISSUEs, CRITERIA, POSITIONs, PREFERENCEs,

while the kinds of relations are:
- REFERS_TO (between PREFERENCEs and POSITIONs),
- SUPPORTS, OBJECTS, COMMENTS (between POSITIONs on one side and ISSUEs, CRITERION, POSITIONS or PREFERENCE on the other).

MULTICRITERIA EVALUATION OF ALTERNATIVES

The objective of this stage is to collaboratively make a multicriteria evaluation of the alternative actions, which have been proposed for an issue, according to a number of predetermined criteria.

The kinds of elements used in this stage are:
ALTERNATIVES, CRITERIONs, VALUE,
while the kind of relations is:
- VALUES (between VALUE and ALTERNATIVE)
- CONCERNING (between VALUE and CRITERION).

DESIGN OF PROGRAMMES

The objective of this stage is to collaboratively design for each of the selected alternative actions a number of programmes for implementing it, and for then each of these programmes its internal structure (subprogrammes, measures, etc.).

The kinds of elements used in this stage, are:
ALTERNATIVE, PROGRAMMEs, POSITIONs, PREFERENCEs,
while the kinds of relations are:
- SUPPORTS, OBJECTS, COMMENTS (between POSITIONs on one side and PROGRAMMEs, POSITIONS or PREFERENCEs on the other),
- REFERS_TO (between PREFERENCEs and POSITIONs),
- IS_PART_OF (between PROGRAMMEs).

DESIGN OF PROJECTS

The objective of this stage is to collaboratively design for each of the selected programmes a number of projects for implementing it, and for each of these projects its internal structure (tasks, subtasks, deliverables, etc.).

The kinds of elements used in this stage are:
PROGRAMMEs, PROJECTs, TASKs, DELIVERABLEs, POSITIONs, PREFERENCEs,

while the kinds of relations are:

- SUPPORTS, OBJECTS, COMMENTS (between POSITIONs on one side and PROJECTs, TASKs, DELIVERABLEs, POSITIONS or PREFERENCEs on the other),
- REFERS_TO (between PREFERENCEs and POSITIONs),
- IS_PART_OF (between PROJECTs on one side and PROJECTs or TASKs on the other, and also between TASKs),
- DELIVERED_BY (between DELIVERABLEs and TASKs).

PROJECT MONITORING

The objective of this stage is to collaboratively monitor each of the projects, concerning both physical implementation and spending financial resources.

The kinds of elements used in this stage are:

TASKs, DELIVERABLEs, ASSIGNMENTs, EXPENSEs, DOCUMENTs, POSITIONs, PREFERENCEs.

while the kinds of relations are:

- DELIVERED_BY (between DELIVERABLEs and TASKs),
- SUPPORTS, OBJECTS, COMMENTS (between POSITIONs on one side and ASSIGNMENTs, EXPENSEs, POSITIONs or PREFERENCEs on the other),
- REFERS_TO (between PREFERENCEs and POSITIONs and between DOCUMENTs and ASSIGNMENTs),
- PART_OF (between ASSIGNMENT and TASK).

References

Adams, N., Fraser, J., Macintosh, A. and McKay-Hubbard, A. (2003). Towards an Ontology for Electronic Transaction Services, *International Journal of Intelligent Systems in Accounting, Finance and Management*, 11: 173–181.

Antoniou, G. and Van Harmelen, F. (2004). A Semantic Web Primer.. The MIT Press: Cambridge, Massachussets.

Benslimane, D., Leclercq, E., Savonnet, M., Terrasse, M.-N. and Yetongnon, K. (2000). On the Definition of Generic Multi-layered Ontologies for Urban Applications, *Computers, Environment and Urban Systems*, 24: 191–214.

Boer, A., Van Engers, T. M., and Winkels, R. G. F. (2003). Using Ontologies for Comparing and Harmonizing Legislation. In The Proceedings of the 9th International Conference on Artificial Intelligence and Law – ICAIL 2003. Edinburgh, Scotland, United Kingdom, June 24–28, 2003.

Breuker, J., Valente, A., and Winkels, R. G. F. (1997). Legal Ontologies: A Functional View. In Visser, P. R. S. and Winkels, R. G. F. (eds.), Proceedings of the First International

Workshop on Legal Ontologies – LEGONT '97, 23–36. University of Melbourne Law School: Melbourne, Australia.

Breuker, J., Elhag, A., Petkov, E., and Winkels, R. G. F. (2002). Ontologies for Legal Information Serving and Knowledge Management. In The Proceedings of the Fifteenth Annual Conference on Legal Knowledge and Information Systems – JURIX 2000. Foundation for Legal Knowledge Based Systems, London, United Kingdom, December 16–17, 2002.

Buckingham, S. S., Motta, E. and Domingue, J. (2000). ScholOnto: An Ontology-based Digital Library Server for Research Documents and Discourse, *International Journal on Digital Libraries*, 3(3): 267–300.

Buckingham, S. S., Uren, V., Li, G., Domingue, J. and Motta, E. (2003). Visualizing Internetworked Argumentation. In Kirschner, P. A., Buckingham, S. S. and Carr, C. S. (eds.), Visualizing Argumentation – Software Tools for Collaborative and Educational Sense-Making. Springer:Great Britain, 185–204, .

Ceccaroni, L. (2004). OntoWEDSS – An Ontology-based Environmental Decision Support System for the Management of Wastewater Treatment Plants. Ph.D. Dissertation, Universitat Polytecnica de Catalunya.

Ceccaroni, L., Cortes, U., and Sanchez-Marre, M. (2000). WaWO – An Ontology Embedded into an Environmental Decision Support System for Wastewater Treatment Plant Management. In the Proceedings of ECAI2000 – Wo9: Application of Ontologies and Problem Solving Methods, 2.1–2.9. Berlin, Germany.

Ceccaroni, L., Cortes, U. and Sanchez-Marre, M. (2004). OntoWEDSS: Augmenting Environmental Decision-support Systems with Ontologies, *Environmental Modelling and Software*, 19: 785–797.

Chandrasekaran, B. and Josephson, J. (1997). The Ontology of Tasks and Methods. Working Notes of the AAAI Spring Symposium on Ontological Engineering, 9–16. Stanford University: CA, USA.

Conklin, J. and Begeman, M. L. (1988). gIBIS: A Hypertext Tool for Exploratory Policy Discussion, *ACM Transactions of Office Information Systems*, 6(4): 303–331.

Conklin, J. and Begeman, M. L. (1989). gIBIS: A Tool for All Reasons, *Journal of the American Society for Information Science*, 40(3): 200–213.

Conklin, J. (2003). Dialog Mapping: Reflections of an Industrial Strength Case Study. In Kirschner, P. A., Buckingham, S. S. and Carr, C. S. (eds.), Visualizing Argumentation – Software Tools for Collaborative and Educational Sense-Making. Springer:Great Britain, 117–136.

Corcho, O., Gomez-Perez, A., Gonzalez-Cabero, R., and Suarez-Figueroa, C. (2004). ODE-VAL: A Tool for Evaluating RDF(S), DAML + OIL, and OWL Concept Taxonomies. In Proceedings of the 1st IFIP Conference on Artificial Intelligence Applications and Innovations (AIAI 2004), 369–382. Toulouse, France, August 22–27, 2004.

Denhardt, R. B. and Hammond, B. R. (1992). Public Administration in Action: Readings, Profiles and Cases. Brooks/Cole Publishing Company: Pacific Grove, California.

Doerr, M. (2003). The CIDOC CRM – an Ontological Approach to Semantic Interoperability of Metadata. Artificial Intelligence Magazine 24(3): 75–92.

Doerr, M., Hunter, J., and Lagoze, C. (2003). Towards a Core Ontology for Information Integration. Journal of Digital Information 4(1).

Fensel, D. (2004). Ontologies: A Silver Bullet for Knowledge Management and Electronic Commerce. Springer: Berlin, Heidelberg, Germany.

Fisher, F. and Forrester, J. (eds). (1993). The Argumentative Turn in Policy Analysis and Planning. Duke University Press: Durham.

Fonseca, F. T., Egenhofer, M. J., Davis, C. A. and Borges, K. A. V. (2000). Ontologies and Knowledge Sharing in Urban GIS, *Computers, Environment and Urban Systems*, 24: 251–271.

Fraser, J., Adams, N., Macintosh, A., McKay-Hubbard, A., Lobo, T. P., Pardo, P. F., Martínez, R. C., and Vallecillo, C. S. (2003). Knowledge Management Applied to e-Government Services: The Use of an Ontology. In The Proceedings of the KMGov2003 – Fourth Working Conference on Knowledge Management in Electronic Government, 116–126. Springer: Rhodes, Greece, May 2003.

Glassee, E., Van Engers, T. M., and Jacobs, A. (2003). POWER: An Integrated Method for Legislation and Regulations from their Design to their Use in E-government Services and Law Enforcement. In Moens, M. F. (ed.), Digitale Wetgeving – Digital Legislation, 175–204. Die Keure Brugge.

Gomez-Perez, A. (2001). Evaluating Ontologies: Cases of Study, *IEEE Intelligent Systems and their Applications – Special Issue on Verification and Application of Ontologies*, 16(3): 391–409.

Gruber, T. R. (1993). A Translation Approach to Portable Ontology Specifications, *Knowledge Acquisition*, 5: 199–220.

Haas, S. W., Pattuelli, M. C., Brown, R. T., and Wilbur, J. (2003). The Understanding Statistical Concepts and Terms in Context: The GovStat Ontology and the Statistical Interactive Glossary. In The Proceedings of the Annual Meeting of the American Society for Information Science and Technology, 193–199. Long Beach, California, USA, October 19–22, 2003.

Hartmann, J., Spyns, P., Giboin, A., Maynard, D., Cuel, R., Suarez-Figueroa, C., and Sure, Y. (2005). Methods for Ontology Evaluation. Deliverable D1.2.3 of the 'Knowledge Web Network of Excelence', IST Programme of the European Union.

Holsapple, C. W. and Joshi, K. D. (2002). A Collaborative Approach to Ontology Design, *Communications of the ACM*, 45(2): 42–47.

Johnson, G. and Scholes, K. (2002). Exploring Corporate Strategy – Text and Cases. (6th ednth ed.). Prentice Hall Financial Times: Harlow, England.

Karacapilidis, N. (2000). Integrating New Information and Communication Technologies in a Group Decision Support System, *International Transaction in Operational Research*, 7: 487–507.

Karacapilidis, N., Loukis, E., and Dimopoulos, St. (2004). A Web-based System for Supporting Structured Collaboration in the Public Sector. In Traunmueller, R. (ed.) Proceedings of Third International Conference EGOV 2004, 218–225. Springer LNCS 3183: Zaragoza, Spain, August 30–September 3, 2004.

Lagouvardos, A. (1999). The CORINE (CO-oRdination of INformation on the Environment) Project. MSc Project, University College London (UCL).

Loukis, E. and Kokolakis, S. (2003). Computer Supported Collaboration in the Public Sector: the ICTE-PAN Project. In Traunmueller, R. (ed.) Proceedings of Second International Conference EGOV 2003, 181–186. Springer LNCS 2739: Prague, Czech Republic, September 1–5, 2003.

Loukis, E. and Kokolakis, S. (2004). An Architecture for a Flexible Public Sector Collaborative Environment based on Business Process Modeling. *Electronic Journal for e-Commerce Technology and Applications*, 1(3) (www.ejeta.org).

Lozano-Tello, A. and Gomez-Perez, A. (2004). ONTOMETRIC: A Method to Choose the Appropriate Ontology, *Journal of Database Management – Special Issue on Ontological Analysis, Evaluation and Engineering of Business Systems Analysis Methods*, 15(2): 1–18.

Lynn, L. E. (1996). Public Management as Art, Science and Profession.. Chatham House Publishers: Chatham, New Jersey.

McCarty, L. T. (1989). A Language for Legal Discourse, I. Basic features. In The Proceedings of the Second International Conference on Artificial Intelligence and Law, 180–189. Vancouver, Canada.

Nagel, S. S. (1984). Public Policy: Goals, Means, and Methods. St. Martin's Press: New York.

Nonaka, I. and Takeuchi, H. (1995). The Knowledge-Creating Company. Oxford University Press Inc: USA.

Organization of Economic Co-operation, Development (OECD) (2003). Promise and Problems of e-Democracy – Challenges of on-line Citizen Engagement.. OECD Publications Service: Paris, France.

Patton, C. V. and Sawicki, D. S. (1993). Basic Methods of Policy Analysis & Planning. (2nd ednnd ed.). Prentice Hall: New Jersey.

Pattuelli, M. C., Brown, R. T., and Wilbur, J. (2003). The GovStat Ontology. In The Proceedings of the National Conference on Digital Government Research, dg.o2003, 355–358. Digital Government Research Center: Boston, MA, USA, May 18–21, 2003.

Perakath, P., Menzel, C., Mayer, R., Fillion, F., Futrell, M., DeWitte, P. and Lingineni, M. (1994). IDEF5 Method Report. Armstrong Laboratory: US Airforce.

Rastogi, P. N. (1992). Public Analysis and Problem Solving for Social Systems – Towards Understanding, Monitoring and Managing Real World Problems. Sage Publications Ltd: Delhi.

Stamper, R. K. (1991). The role of semantics in legal expert systems and legal reasoning, *Ratio Juris*, 4(2): 219–244.

Stamper, R. K. (1996). Signs, Information, Norms and Systems. In Holmqvist, B. and Andersen, P. B. (eds.), Signs of Work. De Bruyter:Berlin, Germany.

Tambouris, E., Gorilas, S., Kavadias, G., Apostolou, D., Abecker, A., Stojanovic, L., and Mentzas, G. (2004). Ontology-Enabled E-gov Service Configuration: An Overview of the OntoGov Project. In Wimmer, M. (ed.) Proceedings of Knowledge Management in Electronic Government – KMGov 2004 – 5th IFIP International Working Conference, 122–127. Springer LNAI 3035: Krems, Austria, May 17–19, 2004.

Uren, V., Buckingham, S. S., Mancini, C., and Li, G. (2004). Modelling Naturalistic Argumentation in Research Literatures. In The Proceedings of the Fourth Workshop of Computational Models of Natural Argument. Valencia, Spain, August 22–27, 2004.

Uschold, M. and Grunninger, M. (1996). Ontologies: Principles, Methods and Applications. Knowledge Engineering Review 11(2).

Valente, A. (1995). Legal Knowledge Engineering: A Modelling Approach. University of Amsterdam, IOS Press: The Hague, The Netherlands.

Valente, A. (2005). Types and Roles of Legal Ontologies. In Benjamin et al., V. R. (eds.), Law and the Semantic Web. Springer Verlag LNAI 3369:Berlin, Heidelberg Germany, 65–76.

Van Engers, T. M., Kordelaar, P. J. M., Den Hartog, J., and Glaseee, E. (2000). POWER: Programme for an Ontology Based Working Environment for Modelling and Use of Regulations and Legislation. In Tjoa, W. and Al-Zobaidie (eds.), Proceedings of the 11th Workshop of Databases and Expert Systems Applications, 327–334. Greenwich, London, Great Britain.

Van Kralingen, R. W. (1995). Frame-based Conceptual Models of Statute Law. Kluwer Law International Computer/Law Series: The Hague, The Netherlands.

Van Kralingen, R. W. (1997). A Conceptual Frame-based Ontology for the Law. In Visser, P. R. S. and Winkels, R. G. F. (eds.), Proceedings of the First International Workshop on Legal Ontologies – LEGONT '97, 23–36. University of Melbourne, Law School, Melbourne, Australia.

Van Kralingen, R. W., Visser, P. R. S., Bench-Capon, T. J. M. and Van den Herik, H. (1999). A Principled Approach to Developing Legal Knowledge Systems, *International Journal of Human Computer Studies*, 51: 1127–1154.

Visser, P. R. S. (1995). Knowledge Specification for Multiple Legal Tasks – A Case Study of the Interaction Problem in the Legal Domain. Kluwer Law International, Computer/Law Series No. 17: The Hague, The Netherlands.

Visser, P. R. S. and Bench-Capon, T. J. M. (1996a). On the Reusability of Ontologies in Knowledge Systems Design. In The Proceedings of the Seventh International Workshop on Database and Expert Systems Applications – DEXA '96, 256–261. Zurich, Switzerland.

Visser, P. R. S. and Bench-Capon, T. J. M. (1996b). The Formal Specification of a Legal Ontology. In Van Kralingen, R. W. (eds.), In The Proceedings of the Ninth International Conference on Legal Knowledge-Based Systems – jurix '96, 15–24. Tilburg, The Netherlands.

Walters, L. C. and Sudweeks, R. R. (1996). Public Policy Analysis: The Next Generation of Theory, *Journal of Socio-Economics*, 25(4): 425–452.

White, L. G. (1994). Policy Analysis as Discourse, *Journal of Policy Analysis and Management*, 13(3): 506–525.