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Table of Contents – Part II

Overcoming Interoperability Weaknesses in e-Government Processes: Organizing and Sharing Knowledge in Regional Development Programs Using Ontologies

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Abstract. European Regional Policy produced several generations of programmes at both National and Regional levels. Such a complex framework tends to increase multi-level governance in the period 2007-2013, promoting a wider participation of stakeholders (including Public Administration, Local Communities, Enterprises, etc). This process has been usually accompanied by e-tools for the management of bottom-up processes, with several instances related to common problems of participation processes. Communication between "programmer" and categories of beneficiaries always presented weakness due to the ineffective system of management knowledge within the process. Relevant issues in the framework of regional development programmes are: Do stakeholders understand the meaning of general and sectoral policies? Are citizens aware of technical instruments implementing such policies? Are they conscious of *ex-ante* comprehensive context analysis and/or can they share possible future scenarios? A way to tackle these problems is the use of ontologies. In this work we present the structural elements of the ontology of regional development programmes analyzing major steps of the ontology design and nodal phases of the ontology building (i.e. consensus on relations and restrictions, switch from glossary to taxonomy). The result of such an application is an ontology of regional development containing more than one hundred classes.

Keywords: Regional Development Programmes, Context Based Approach, Semantic Interoperability, Ontology.

1 Introduction

From operative research to technical applications, organization and sharing of knowledge is a crucial step. In the field of "planning", intended not only as a theory but mainly as a practice, scientists and technicians develop their rational exercise on a multi-sectorial knowledge framework. In the process it always includes several active bodies, with different functions and responsibilities. Such an inclusion is mainly increased by the application of participative techniques (based on Internet and ICT e-government tools) and the role of communication, in planning process, has considerably increased during the last

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decades (Tilio et al. 2009). Communication requires a sharing of ontologies between communicating parties (Mark, Smith and Tversky, 1997) and it also needs new tools in order to facilitate a bottom-up participation process (Knapp and Coors, 2008).

The theme of knowledge management has assumed relevant importance in planning processes, especially due to the contribution of GIS, Spatial Data Infrastructures (SDI), WEB-GIS, etc. Such starting considerations remark the role of an ontological approach in developing planning theories and practices, considering the knowledge interchange issue dominating the process.

Research in ontology as the basis for the development of knowledge-interchange standards has expanded in recent years (Gruber, 1993). But in many cases the effort to build a sectorial ontology is not justified in a short term view as it brings only marginal operative contributions to the technical development of an action, a project or a program. Some resistances in applying planning ontologies come from the public sector. Why should a Public Administration invest time and resources in developing an ontological approach for planning purposes?

Probably a cost-benefit evaluation, based on the state of the art of ontology applications, would justify the current approach of Public Bodies, but we present a new perspective connected to the application of ontologies in local development programming with strong implications on ex-ante assessment of efficacy and effectiveness of adopted policies.

Within the complex framework of meaning concerning territorial classification and planning/programming specific contents, we agree on the assumption that a powerful tool to increase rationality of knowledge is the "ontology". Such an approach allows us to demonstrate that, in order to have a ready to use ontology, we have to look for different sectorial ontologies, assuming that no single ontology can capture all aspects of reality, but that we can build particular ontologies for specific aspects of physical, cognitive, administrative or legal reality (Frank, 1996). One might say: "Probably it will be possible to build the "semantic web" but, at present time, we want to organize a portion of a sectorial knowledge in order to use it".

This paper suggests considerations connected to the issue of developing a "ready to use" ontology applied to the planning sector. This approach implies a modelling activitie and a knowledge engineering process in a multidisciplinary framework (Las Casas and Scardaccione, 2008).

In this paper we describe the design and development processes of a sectorial ontology, the "Regional Development Ontology" ReDO. In particular we refer to the complex framework of programming tools generated from the European Union Regional Policies.

2 From Definitions to the Application of the Ontology

A philosopher would define an ontology as the "discipline dealing with theories of being". The informatics science approach has significantly transformed the meaning of the term. A well-posed definition has been suggested by Ferraris (2005): "the theory of objects and their relations". Overcoming the traditional philosophical definition of ontology, we will use a slightly different notion (proposed, among others, by

Grüber): a specific ontology seen *as a model* can be defined as "the explicit specification of an abstract, simplified view of a world we desire to represent" (Gruber, 1995).

According with Genesereth and Nilsson (1987), the base for representing knowledge is the process of conceptualization: objects, concepts and other entities that are assumed to exist in some area of interest and the relationships that hold among them. The term "ontology" describes the explicit specification of a conceptualization (Gruber, 1993) of a 'part of reality'.

In information science ontologies describe a particular way to understand a part of the world (Frank, 2008). Murgante et al. (2009) refer to "ontology" as a meta-model of reality, where concepts and relations are used as boxes of the interpretative model, generating rules and bonds for relations.

For each data base it is possible (mainly necessary) to define a specific ontology (Laurini and Murgante, 2008). This affirmation implies that we can have *"n"* local ontologies that should communicate each-others to build a shared knowledge. Laurini and Murgante (2008) define the "domain ontology": an higher level ontology connecting different local level ontologies as "mediators" promoting the interoperability among different data bases. This represents an important field for recent researches and applications with many relevant results but with no general or standard solutions. This work presents the ReDO research concerning a sectorial ontology: the regional development ontology.

3 "Ready to Use" Ontology

"In order to be useful, an ontology has to be shared" (Damiani, 2009). If we consider an international community, this concept strongly assumes the first priority of the research, but also in our "sectorial ready to use ontology" oriented to improve the planning process we need an agreement of stakeholders participating the process.

In order to minimize the effort (or, in other words, the cost) of adopting ontology in the planning process, we suggest to prefer a technical approach. We are in the case described by Corallo (2005), where a limited group of experts defines the ontology and the community adopts it (or accepts it) as a tool of the process. The other case is that the ontology is collectively defined and developed, in order to immediately improve the collaborative definition of the world.

Another general issue to be faced are perspectives of the ontology. It has to be usable for future applications and perspective users (human beings or intelligent agents) and the usage (cataloguing, searching, exchanging information) has to be considered in the design of the ontological structure.

A way to characterize a "planning ontology" is to propose a definition like geographical kinds ontology. Such strong simplification underlines a central concept: the spatial dimension of planning. This represents an additional element to the traditional approach in ontology design, because it implies new relations between concepts, based on the spatial relation between attributes, even considered in a dynamic view (the space changes continuously and in two different times we will have different relations among objects, people, organizations, environment, etc.).

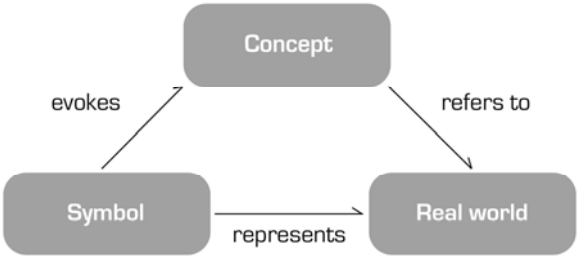

Fig. 1. The meaning triangle

"The meaning triangle" (figure 1) simplifies the relations at the base of the process of conceptualization of "reality". It refers to a process of observation of the real world and to a corresponding process of conceptual representation. Such observation cannot be considered fully complete but it depends on the observer point of view. His interpretation of the real world strongly depends on his cultural back-ground, his interests, his relation with the reality, etc.

The common experience of all observations of reality shows the presence of errors, imprecisions and uncertainties in results. There are various reasons for such limitations of the - physical, technical and cognitive - observation process, but they are fundamental and nearly nothing can be measured with absolute accuracy (Frank, 1996).

These considerations influence the process of building an ontology in the domain of planning. Indeed, planning processes are based on the interactions among politicians, technicians, stakeholders and context (intended not only in the physical dimensions but also in social, cultural and economic ones); therefore many points of views produce different visions, sometimes conflicting in terms of objectives, priorities, relevance, etc. The interaction of different actors on the scene of the plan generates problems connected with communication. A very important matter resides in the language and especially in the level of actors agreement on concepts and their definitions. It is the case of different databases containing complementary information but with no opportunity to "collaborate" in building a wider data-knowledge due to problems in meta-data, data-types, etc. It corresponds to a problem of interoperability.

This is a common situation in planning: different institutional (public) or private bodies build their own plans; they hold information systems (generally complex data infrastructures) containing general and specific data; each plan corresponds to a process of analysis and knowledge building, without opportunity of knowledge capitalization among different plans.

In this work we refer especially to the problems of communication among the community of actors involved in programming regional development, according to European Union regional policy.

4 Ontologies in Planning and Programming: ReDO Application

The ReDO research analysed primarily the phase of "ontology design". This is a crucial step in the process of applying ontologies to planning (or programming) processes.

Especially, attention should be paid to the structural elements of the ontology: domain (or 'scope' of the ontology), concepts ('classes'), hierarchy, attributes for the concepts, restriction and relations between concepts, instances. The definition of such elements represents the 'ontology design'.

According to the general scheme proposed by Ceravolo and Damiani (2008), we identified the following steps for the ontology design:

- step 1: scope definition;
- step 2: class and slot design;
- step 3: constraints' enforcement;
- step 4: instances creation.

The domain is the abstraction of the reality we want to represent. In the specific case study, the scope is represented by a complex reality: the program and its relationships with the context of implementation and with the community of actors and beneficiaries, the procedural scheme of implementation and management. It is composed by physical elements, relations among them, value systems, program actions, social issues, policy goals. In order to improve rationality process, the first issue is to circumscribe the domain. According to recent studies (Ceravolo and Damiani, 2008; Tilio et al. 2009), the fundamental questions to be answered in this phase are:

- Q1: Which is the portion of real world we want to describe through the ontology?
- Q2: Which are the answers we expect from our ontology?
- Q3: Which is the spatial dimension of the domain (in other words: "where does the ontology work")?
- Q4: Is the domain open or close?

Our objective is to represent European operative programs OPs(Q1) considered according to both the strategic component and the operative/procedural ones. In a general view, several European policies are implemented by OPs 2007-2013 at national, regional or interregional scale.

Answering Q3 question might appear to be a consequence of the administrative border of each OP (Region, Country, aggregation of Regions). This choice might be an element of strong simplification of the reality and so it could imply errors in gathered evaluations. A way to control such errors is to consider the domain as open in space, time and objects (Q4).

The second methodological question (Q2) is probably the key of the ontology design. What do we expect from our work? In a synthetic view, we intended to provide an operative tool for managing and control OPs, reinforcing the quality of interactions between each OP and the category of beneficiaries also improving participation in local development processes. This ontological representation aims to obtain an improvement of rationality in policy making. This could be possible if contradictions and conflicts among different planning tools are removed or at least reduced. The activity (considered as a bottom-up and participated approach) leading to such an ambitious objective is the evaluation intended as a comprehensive and context based one (Las Casas and Scorza 2009).

The operative phases of ReDO build-up process are listed and commented in the synoptic table (table1). It is important to highlight that it is a report of a real process carried during the ReDO research and not a methodological approach.

A brief description of each phase is provided in the synoptic table but it is important to consider some crucial aspects: in the passage from thesaurus to taxonomy the expert team agreed on a restriction of elements composing the ontology. This happened out of any methodological prevision, and we can say it corresponds to a concrete process pear to pear agreement on conceptualization. Only the concept considered useful by the community of experts was included in the ontology. Probably we could admit also the opposite case (the enlargement of thesaurus), but the relevant aspect rests in the agreement and sharing process as a necessary component of building an ontology.

Table 1. ReDO synoptic table

Phases		Description	Output
1	Domain definition	Identification of ontology "scope". According to main questions described above, we defined the domain including the relevant aspects of EU OPs management and evaluation: components, actors, policies, tools, etc.	Domain
2	Concept identification	According to ontology structure, a team of experts (technicians and scientists) identified the relevant concepts for ReDO purposes after an analysis of 2007/2013 POs (PO ERDF Basilicata, PO ERDF Puglia, PO ERDF Campania - Italy).	Concept list (about 110 concepts)
3	Thesaurus	For each concept, the research team identified the pertinent definition using accredited sources. The result is a glossary (thesaurus) and it represents the first operative output of the process.	Thesaurus (about 110 concepts and definitions)
4	Extraction of ontology classes from thesaurus	Within the whole thesaurus, the research team defined the ontology classes through a pear to pear negotiation.	Classes (61 ReDO classes)
5	Taxonomy development	The 61 classes have been organized in a taxonomy: a hierarchical structure based on the taxonomic relation "IS_A"	Taxonomy
6	Application of attributes and restrictions to each class	Attributes and restrictions allow to realize an operative characterization of a class. The definition itself is an attribute of a class. Attributes correspond to data/information required for the individuals of the class. Restrictions are rules for class population.	Attributes Restrictions
7	Definition of relations among classes	Relations among classes allowed to represent procedures and functions connected to the management and the evaluation of OPs	Relations
8	Ontology population	After the construction of the ontological structure a very important step is the population of the ontology. It is the phase of operative representation of the domain in ReDO knowledge management tool.	Instances

5 ReDO Main Classes and Relations

In this work we present a description of the main classes and relations of ReDO ontology. It is also important to identify sources used for Thesaurus construction. In the below table there is a list of relevant sources we used. It is not a complete list of accredited sources in the domain of planning but a selection of useful tools for operative ontological applications.

Table 2. ReDO sources

Thesaurus Sources	Type	Link
1 "Summaries of EU legislation": everything you want to know about European legislation.	GLOSSARY	http://europa.eu/scadplus /glossary/index_en.ht
2 "Ministero del Lavoro e delle Politiche Sociali": Portale Europa Lavoro.	GLOSSARY	http://www.lavoro.gov.it/Lavoro /Europalavoro/SezioneEuropaLavoro /Utilities/Glossario
3 Princeton University – WordNet 3.0	Standard exicon - Dictionary	http://wordnetweb.princeton.edu /perl/webwn
4 California General Plan Glossary	GLOSSARY	http://www.cproundtable.org/publications /california-general-plan-glossary/
5 The United Nations Statistics Division (UNSD) of the Department of Economic and Social Affairs (DESA)	GLOSSARY	http://data.un.org/Glossary.aspx
6 Glossary of statistical terms OECD (Organization for Economic Co-operation and Development)	GLOSSARY	http://stats.oecd.org/glossary/

Results of ReDO research led us to define five main classes of ontology domain for our application:

1. Plan, defined as a "Written account of intended future course of action (scheme) aimed at achieving specific goal(s) or objective(s) within a specific timeframe. It explains in detail what needs to be done, when, how, and by whom, and often includes best case, expected case, and worst case scenarios".
2. Project, defined as a "Planned set of interrelated tasks to be executed over a fixed period and within a certain cost and other limitations".
3. Policy, defined as a "A specific statement of principles or of guiding actions implying clear commitment but not mandatory. A general direction that a governmental agency sets to follow, in order to meet its goals and objectives before undertaking an action program".
4. Tools, defined as "Financial, normative and methodological instruments for policies implementation".
5. Actors, defined as "Groups of private, public, no-profit bodies involved in development processes".

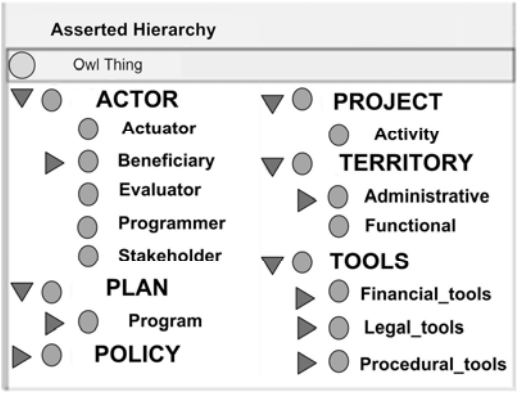

Fig. 2. ReDO main classes

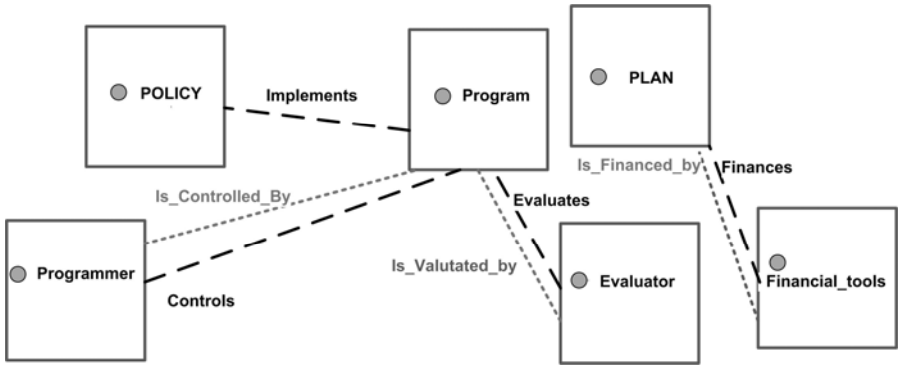

Fig. 3. ReDO relevant relations

Among ReDO sets of relations the relevant ones are:

- Finances/Is_Financed_By: in the processes of planning and management of local development financial tools represent a key variable. Through this relation, we make explicit the dependency between classes and financial aspects. This explanation has implications for operations related to the management process which often presents problems of overlapping expertise and resources.
- Controls/Is_Controlled_By: responsibility, intended both in terms of ownership of the programmatic function and in terms of process control (implementation and management of the program or of an intervention), is a key relationship in the design of the ontological model. In facts, the OPs management structure does not allow easy attribution of such functions within the complex system of programming. This leads to problems in connecting program and territory in terms of relationships between involved actors. In particular, the beneficiaries find it difficult to relate with the appropriate decision-making direction for specific issues.
- Implements/Is_Implemented_By: this relation expresses the ownership of the process of implementing policies, programs and interventions. This is a function

given in different ways: for " hierarchical transfer" if the program directly implements one or more strategies (policies), for "competition" if policies are implemented by projects passing through a procedure of public competition (i.e. “Call for proposal”).

- Evaluates/Is_Evaluated_By: the identification of the evaluation function within the ontological structure is one of the key results of ReDO. The evaluation function is always unclear in UE Ops, for both periods 2000-2006 and 2007-2013. In order to clearly express the fields (or classes) for which the evaluator (considered one of the key actors in the process) will exert his task is the basis for a proper comprehensive evaluation process (Las Casas and Scorza 2009).

6 Program Structure and Ontology Structure

Cognitive structures are often arranged in a way that wide concepts are subdivided into narrower ones. At first, they seem to follow a hierarchical structure, where the elements of the upper level are subdivided in smaller ones, such that a group of smaller ones makes up exactly one unit at the higher level. But this is not necessarily the case and in general a directed acyclic graph can be observed. There is an important parallelism between the structure of an ontology and the program structure. The program structure is a hierarchical structure connecting general and specific objectives with activities and results. The logical nexus is based on cause-effect relation.

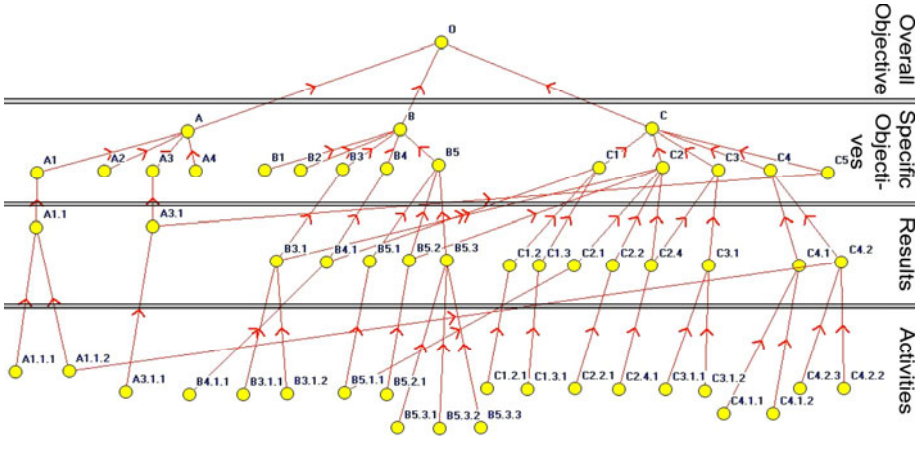

Fig. 4. OP Basilicata 2000-2006 – axis 4, Program structure

This parallelism, connected to the nature of the programming domain, allows us to identify the ontology as the better knowledge management tool in the field of programming. The current tools for managing ontologies (in this work we used the Protegé software) do not allow to integrate the spatial dimension within the ontological representation. Working in the field of territorial programming is an important weakness and a perspective at the same time.

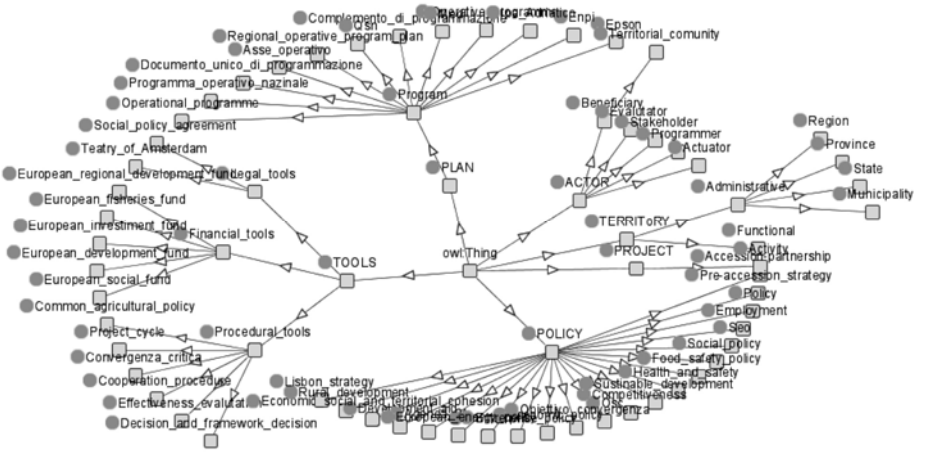

Fig. 5. ReDO ontology

7 Conclusions

The ReDO research provided several interesting outputs: the ReDO ontology, a tested procedure for ontology design, methodological remarks regarding the role of users (or stakeholders) interaction in the process of building-up the ontology. Indeed, the level of participation of technicians, scientists and potential users in the process of ontology development is directly proportional to the usability of such knowledge management tools, especially in the field of planning.

As mentioned above, problems still remain in the connection of ReDO to spatial dimension and especially the connection with Spatial Data Infrastructures.

As experimented in ReDO research, the ontological representation of the program gives important contribution to control and evaluate the program structure logic. Previous works (Las Casas and Scorza, 2008, 2009) show how logical weaknesses in program structures determine a lack of efficacy and effectiveness on the whole policy. Therefore, one of the most important applications of this tool concerns the field of program evaluation, intended as a comprehensive process (Scorza, 2008).

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