That's ReDO: Ontologies and Regional Development Planning

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Abstract. European Cohesion Policy generates several programs at territorial levels. An evident trend is the increasing of multi-level governance in the period 2007-2013, promoting a wider participation to programming processes. It is possible to affirm that new instances are coming out. We refer to problems generally connected with participation processes. The relation between problems in knowledge management and ineffective impacts of local development plans is confirmed. Therefore, the central role of communication determines relevant issues regarding the ability to understand the meaning of general and sectoral policies by stake holders, the awareness of citizens to manage 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 and an application of ReDO ontology (Regional Development Ontology) analyzing major steps of ontology design and nodal phases of ontology building (i.e. consensus on relations and restrictions, and switch from glossary to taxonomy).

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

1 Introduction

The planning process usually faces a complex and multidisciplinary dimension in which the knowledge management function increased its relevance. In planning activities, scientists and technicians develop their contributions on a multi-sectoral knowledge framework. The process 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 decades [20] [21] [22].

Ontologies assume a potential role in supporting and developing knowledge interchange issue dominating the process. Communication requires a sharing of ontologies between communicating parties [16] and it also needs new tools in order to facilitate a bottom-up participation process [9].

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Research in ontology as the basis for the development of knowledge-interchange standards has expanded in recent years [7].

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".

This paper suggests considerations connected to the issue of developing a "ready to use" ontology applied to the planning process. This approach implies a modelling activity and a knowledge engineering process in a multidisciplinary framework [10].

In this paper we describe the design and development processes of a sectoral ontology, the "Regional Development Ontology" (ReDO). In particular we propose the use of such tool for the representation of a sample of five Regional Operative Programs of the EU Programming Period 2007-2013.

2 How to Define It?

In order to discuss the approach and results of the research we have to start from a definition of ontology. In fact, the term 'ontology' can lead to misunderstandings connected to its adoption in different scientific or technical field of application.

Let's start from our definition of ontology: "Explicit and formal model of a domain". In our application we identified in the ontological approach a way to define a model concerning with the planning process. So we developed a representation of 'the plan' based on a specific ontology designed in order to accomplish the general objective of a deeper rationalization of the planning process aiming to achieve more equity, more effectiveness and more sustainability for the decision concerning territorial development. This representation has to be 'formal'; it means that it should be symbolic and mechanized (better computerized). In fact, we look at the complex process of sharing knowledge and information about 'the plan' among the community of stake holders directly or indirectly involved in the process. This aspect implies some specific instances: to use a shared interpretation model and so a shared symbology for the identification and understanding of the meaning of a concept included into ontology; to build a framework in order to develop functions and queries, to analyse and to validate the representation using ICT tools. Regarding the concept of 'domain' we assume the vision by Grüber [8] speaking of 'a subset of knowledge, dealt from a certain point of view".

This definition of ontology coexists with several other definitions depending on the field of application.

If the philosopher would define ontology as the "discipline dealing with theories of being", the informatics science significantly transformed the meaning of the term. A well-posed definition has been suggested by Ferraris [3]: "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" [8].

According with Genesereth and Nilsson [6], 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 [7] of a ‘part of reality’.

In information science ontologies describe a particular way to understand a part of the world [5]. Murgante et al. [14] 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 [13]. This affirmation implies that we can have “n” local ontologies that should communicate each-others to build a shared knowledge. Laurini and Murgante [13] 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.

3 Towards ‘Usability’

“In order to be useful, an ontology has to be shared” [2]. If we consider an international community, this concept strongly assumes the first priority of the research, but also in our “sectoral 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 for developing ontology. We are in the case described by Corallo [1], 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.

As a representation of real world is the result of a process of observation (or in other words a “building knowledge process” – see also [4]), such observation strongly depends on the observer point of view. His interpretation of the real world depends in turn on his cultural back-ground, his interests, his relation with the reality, etc. So we have to admit 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 [4].

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.

4 ReDO Design and Structure

After previous preliminary considerations, in this section we describe main stages of the operative research we called ReDO (Regional Development Ontology).

The first step regards the phase of "ontology design". It represents a crucial step in the procedure of applying ontologies to planning processes. Above all, attention should be paid to the structural elements of ontology: domain (or 'scope' of ontology), concepts ('classes'), hierarchy, attributes for concepts, restriction and relations between concepts, instances. The definition of such elements represents the 'ontology design'.

Our procedural scheme includes four steps [17] for ontology design:

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

The domain is an abstraction of 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 [21] [2], 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 strategic and operative/procedural components. In a general view, several European policies are implemented by OPs 2007-2013 at national, regional or interregional scale.

Answering Q3 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 reality and therefore, 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).

Table 1. ReDO synoptic table [17]

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

The second methodological question (Q2) is probably the key of ontology design. What do we expect from our work? In a synthetic view, we intend 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 evaluation, intended as a comprehensive and context based one [11]. The operative phases of ReDO build-up process are listed and commented in the synoptic table (table1) [18].

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 has happened out of any methodological prevision, and we can say it corresponds to a concrete pear to pear agreement process 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.

It is important to underline that this representation is a report of a real process carried during ReDO research, and it has to be considered as a result of the methodological approach described in this work.

ReDO ontology is based on a simple structure of classes and relations. This simple model is oriented to usability.

We defined 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 it 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 specific statement of principles or of guiding actions implying clear but not mandatory commitment. 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".

Among ReDO sets of relations, 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 in terms of both ownership of programmatic function and 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, OPs management structure does not allow easy attribution of such functions within the complex programming system. 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 a 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 has always been unclear in UE Ops, for both periods 2000-2006 and 2007-2013. In order to clearly express 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 [11].

The figure 1 shows a graph in which main classes are connected through the described relations.

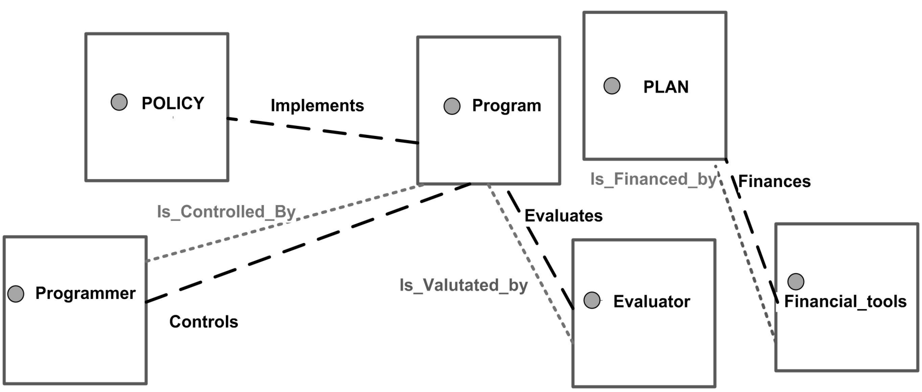

Fig. 1. ReDO relevant relations

5 Cognitive Structure VS Program Structure

The conceptual base of the application considers the analogy between what we call 'program structure' [11] and a 'cognitive structure'.

As described in previous works [18], program structure is the hierarchy between strategic and operative components of a plan, linked together by a logic nexus. In the following figure an example of program structure representation concerning the analysis of the POP FESR Basilicata 2000-2006 is proposed. In the figure 2, it is possible to identify the strategic component of the plan (overall and specific objectives) and the operative ones (results and activities). Through this analysis we obtained a graph – in particular a tree – in which nodes are components of the program and arcs are representative of cause-effect relations.

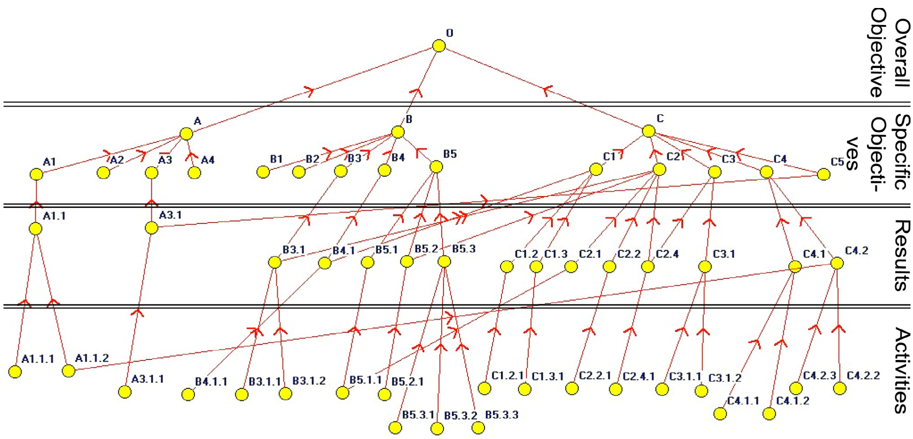

Fig. 2. OP Basilicata 2000-2006 – axis 4, Program structure

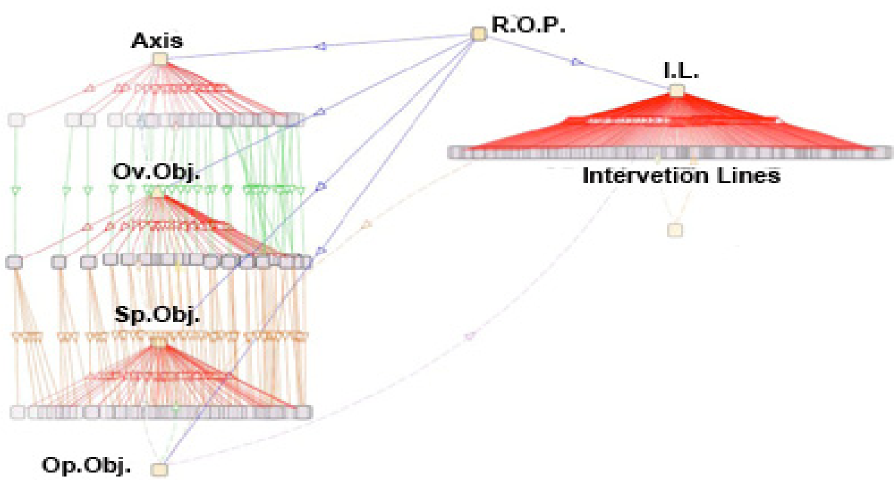

Fig. 3. ReDO ontology

On the other hand, 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 elements of the upper level are subdivided in smaller ones, such that a group of smaller ones makes up exactly one unit at a 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 structure of an ontology and program structure.

For the aim of the research the static representation of program structure as an oriented graph does not verify the complex set of relationships connected to plan implementation phase. It refers to the functions of management and control, implementation of interventions, evaluation of impacts, etc..

Therefore, we identified ontology as a comprehensive knowledge management tool in planning field.

6 Five Regional Operative Programs and One Ontology

In order to test ontology as a model applied to local development planning, a wide application has been conducted on a sample of five Italian Regional Operative Programs 2007-2013 (R.O.P.) implementing EU regional policies.

The sample of experimentation has been selected in order to include a wide range of cases of Regions belonging to different UE mainstream objectives.

Table 2. Regional Operative Programs represented into ReDO ontology

Region		Program	Objective UE 2007-2013
1	Basilicata	O.P. ERDF Basilicata 2007-2013	Convergence (phasing out)
2	Puglia	O.P. ERDF Puglia 2007-2013	Convergence
3	Sardegna	O.P. ERDF Sardegna 2007-2013	Convergence (phasing in)
4	Emilia Romagna	O.P. ERDF Emilia Romagna 2007-2013	Regional Competitiveness and Employment
8	Toscana	O.P. ERDF Toscana 2007-2013	Regional Competitiveness and Employment

We observe how such programs are characterized by sectoral planning framework articulated in a program structure compatible with ReDO model.

The sample has been compared on two testing levels:

- first, we proceeded to analyse and represent single R.O.P., evaluating obtained results;
- in the second phase of the work, we developed an ontology containing all programs.

This extension of the representation has allowed to express comparisons and evaluations among operative programs.

Table 3. Individuals' encoding

Classes	**encoding**
Axis	A_1_'Region Name'
Overall Objective	OG_1_'Region Name'
Specific Objective	OS_1.1_'Region Name'
Operative Objective	OP_1.1.1_'Region Name'
Intervention Line	LI_1.1.1a_'Region Name'

In order to allow a proper management of this huge information system, a unique feature encoding in ReDO has been adopted. We proceeded, according to the description given in the below table, through the identification of elements belonging to R.O.P. hierarchical structure and specifying each R.O.P. by its name (ie. the name of the region).

At the end of the study we obtained an ontology with more than six hundred items: a very complex network. This is the dimension of the information baggage we used to deal with during the phases of plan implementation, management and evaluation.

At this step the useful ontological tools provided by Protégé helped to interrogate the network producing comparative results.

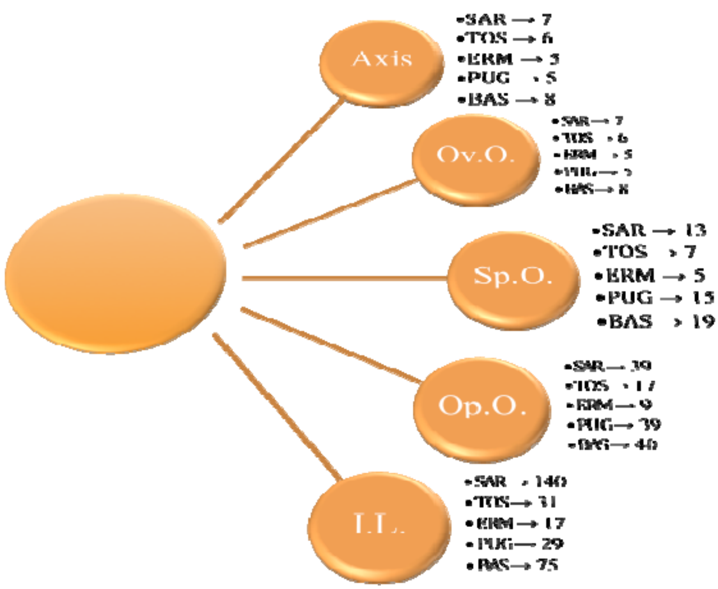

Fig. 4. ReDO in numbers

Some critical considerations emerged: if you are a planner, you should hold the knowledge about how to deal with a complex plan or program; if you are an applied technician you will understand and manage sectoral aspects of the plan connected to specific knowledge; but, if you are a politicians, a stake holder or a final beneficiary of a program, then which tools have you in order to understand and implement plan previsions, especially in a participative dimension? What we want to underline is that if we intend to implement a participative bottom up approach in local development, we have to provide not only technicians, but also common citizens of effective knowledge management tools in order to build-up a process of knowledge sharing.

Managing complexity is one of the permanent issues of planning theory, but such instance has increased in priority in incoming scenarios of shared planning in ICT environment. We think that ReDO assumes a relevant role as an applied knowledge management tool combining functions, queries, analytical and quantitative tools derived by other fields of application. In fact, the result of the research has allowed several interesting outputs: to investigate structures of programs, to compare contents of programs, to classify contents of each program within the framework of relations defined in the ontology, to allow semantic queries and navigation within the complex network.

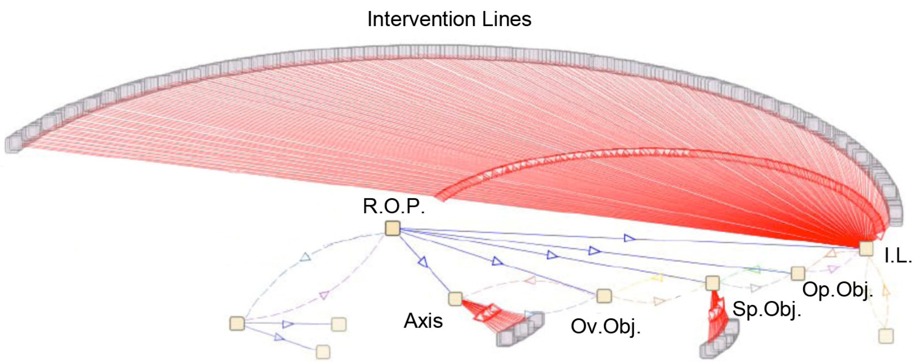

Fig. 5. ReDO R.O.P. network

7 Conclusions

ReDO ontology is the main output of the research. It is the result of 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 usability of such knowledge management tools, especially in the field of planning [15]. This consideration identifies ReDO as a pure research output but it could bring to operative application starting from the ReDO model.

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 it is an important weakness and a perspective at the same time.

So, in order to assume ontology as a comprehensive DSS (Decision Support System) the problem of integration of Spatial Data Infrastructure should be faced.

To adopt effective knowledge management systems, responding to broad accessibility criteria, will allows 'program actors' (decision makers, citizens, stake holders) to have a complete information to the domain of interest.

As experimented in ReDO research, the ontological representation of the program gives important contribution to control and evaluate the program structure logic. Previous works [11] [12] 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 [18].

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