eGovernment Ontologies: Social Participation in Building and Evolution

Alessia Barbagallo
TXT e-solution, Italy
alessia.barbagallo@txtgroup.com

Antonio De Nicola
IASI-CNR, Italy
denicola@iasi.cnr.it

Michele Missikoff
IASI-CNR, Italy
missikoff@iasi.cnr.it

Abstract

eGovernment has the aim of developing computer-based solutions to support the interaction of citizens with the public institutions and, more in general, to improve their participation in the public and social life. Semantic technologies, used to develop advanced eGovernment solutions, require eGovernment ontologies. The latter, to be effective, must be built within a participative, social process. Such a socially participative method must be adopted also in later phases, when the ontology needs to be periodically updated and maintained. In this paper we present the SOBE (Social Ontology Building and Evolution) Methodology, based on a clearly defined social process, with clearly defined intermediate steps, actors and roles, and outcomes produced.

1. Introduction

One of the key objectives of semantic technologies applied to eGovernment is to provide better services while enhancing the participation of citizens to the public life. Semantic technologies, to be effective, need to be based on sound ontologies, largely shared within the participating social communities [9]. Therefore, we think that a wide involvement of the citizens is necessary also in the development of the semantic infrastructure necessary to support new forms of civil participation and, in particular, in ontology building and evolution.

An ontology represents a rich conceptual model of (a fragment of) the reality[1], typically focusing on a specific domain. Due to the large variety of complex, articulated domains on which the public government is actively involved (from transportation to public security, from health to education and culture, from environment protection to housing), it is not possible to build one single, large eGovernment ontology. The experience shows that it is necessary to partition the effort, building several specific domain ontologies. But such ontologies are not disjoint, therefore the final semantic infrastructure will be based on a federation of domain ontologies. Such an ontology federation will be typically achieved proceeding bottom-up, i.e., starting from the development of individual domain ontologies and then identifying their relationships and overlappings.

Key problem is represented by the fact that, being an ontology a conceptual image of the reality, it needs to evolve in parallel to the evolution of the latter. Therefore, we need to foresee a framework in which after the initial development, an ontology is properly maintained and regularly updated. We refer to this process as ontology evolution. When both the ontology building and evolution take place with a large participation of citizens, we refer to the processes as social ontology building and evolution (SOBE). Social participation in ontology building is not an easy achievement: first of all it requires a collaborative attitude in defining the ontology scope and purposes [1], [2]. To this end, it is useful to deploy an effective methodology and computer-based solutions to support this complex collaborative process.

The use of ontologies in advanced public services has been put forward by several FP6 projects, that have produced encouraging results. Among those we cite: Terregov [20], OntoGov [21], QUALEG [22], and LD-CAST [23]. However, in such projects the attention was mainly focused on the use of ontologies to develop advanced eGovernment services, while the problem of building and evolving such ontologies was not systematically addressed.

This paper proposes the SOBE Methodology, characterized by an extensive participation of citizens throughout the process. The latter is clearly defined, with intermediate outcomes, and the precise indications on where the intervention of citizens is expected and what are their tasks. The SOBE Methodology has been built using the experience acquired in previous projects, both in eGovernment and eBusiness, and it is based on the UPON methodology [1]. A first proof of concept has been carried out.

Our proposal is aligned with the strategies of the European Commission (EC). In particular, according to a recent document of the EC on the future of

[1] A more precise definition is in [19], [8]: *An ontology is a formal specification of a shared conceptualization.*

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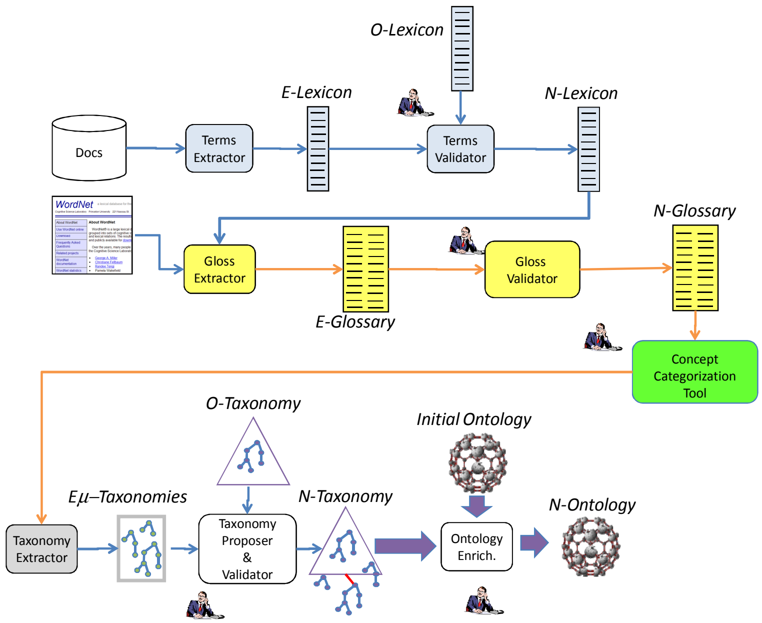

Figure 1 Overview of the ontology evolution process

eGovernment[2], there is the indication to "use technique of social participation and collaborative production made possible by ICT. In particular, among the main issues indicated there are: empowering citizens, inclusion and participation, and transparency. Our proposal goes in this direction. In fact, we propose a method that guarantees eGovernment ontologies to be open, transparent, and shared by the large majority of citizens. Then, when creating advanced public services, based on a shared reference ontology, there will be higher options to achieve transparency and inclusion in what is delivered to the citizens.

The rest of the paper is organized as follows. In Section 2, we describe the whole ontology evolution process and we identify the milestones where the community is asked to reach a consensus. In Section 3, we present the different aspects of the consensus process: the community of interest (COI) and how to reach consensus. In Section 4, we present the case study where we are going to use the SOBE methodology and, in Section 5, we present related works. Finally, in Section 6, we present conclusions and future work. The paper is closed by an Appendix where some details on the knowledge structures are elaborated.

[2] "Visions and priorities for eGovernment in Europe - Orientations for a post 2010 eGovernment Action Plan". From: http://ec.europa.eu/information_society/activities/egovernment/docs/2015_background_doc-210-pvt.pdf

2. The Ontology Evolution Process

As anticipated, within the complex domain of semantic infrastructures for eGovernment, in this paper, we focus on the last letter of the SOBE Methodology: the ontology evolution process, taking place in a highly participative social environment. The *ontology evolution process* here presented is derived from the UPON methodology [1] and is currently applied in the COIN European project [4].

2.1 The UPON Methodology

UPON is a methodology for ontology building from scratch, inspired by the Unified Process [5], a software engineering methodology. A characterizing feature of the UPON methodology is its incremental nature, reflected by the outcomes produced in the different phases of the development process. Firstly, the relevant terms in the domain are identified and gathered in a *lexicon*; then the latter is progressively enriched with definitions, yielding a *glossary*; adding to it the specialisation relationships allows a *taxonomy* to be produced. Finally, further enrichments and a final formalization produce the sought *domain ontology*.

The proposed *ontology evolution process* (Figure 1) is structured in phases, according to the UPON. Here we assume that an initial ontology already exists. Then, the key idea is to start from a corpus of relevant domain-specific documents, to analyse them to see if the reality they reflect has changed with respect to what modelled in the ontology. If positive, we need to understand to what extent the ontology needs to change accordingly.

2.2 Steps and intermediate structures

Starting from an existing ontology we extract the terminological part, i.e., the ***O-Lexicon***. Then, new relevant terms in the domain are automatically extracted, by analysing the reference Corpus, and gathered in the corresponding lexicon, i.e., the (extracted) ***E-Lexicon***. The terms belonging to the *E-Lexicon*, and not belonging to the *O-Lexicon* are socially validated by the community of interest, and gathered in the new lexicon: ***N-Lexicon*** (milestone 1). The latter is progressively enriched with definitions extracted from existing resources (e.g., Wordnet, Wikipedia), yielding a differential glossary, i.e., the ***E-Glossary***. The latter is then validated by the COI. The validation consists in analysing the *glossary entries*, aiming at choosing the most suitable definitions, when more than one is available, and collapsing the synonyms in a single entry in the glossary (milestone 2). The result of this step is gathered in the ***N-Glossary***. Then the COI categorizes every *glossary entry* by associating a kind to it (*Object, Process, Actor*, according to the OPAL framework [6]). Gloss validation and "kind" assignment is performed by the COI with a consensus building process (milestone 3). Starting from the newly acquired concepts definitions, an advanced NLP technique allows hyponyms and other related concepts to be identified, producing a set of micro-taxonomies: ***Eμ-Taxonomies***. An *Eμ-Taxonomy* is a specialization relation between two concepts. Then, the *Eμ-Taxonomies* are merged with the taxonomy of the initial ontology (i.e., ***O-Taxonomy***) producing the ***N-Taxonomy*** by means of a social consensus process (milestone 4). Finally, the ontology is enriched with other relationships (e.g., partOf) by the COI (milestone 5).

3. The Social Consensus Process

A consensus process is obtained when a group of people, starting from diverging positions, collaborates to make the best possible decision. Concerns are raised and resolved, until all voices are heard and large convergences are achieved. During the process, a proposal ceases to be the property of the presenter and, with a collective refinement, a solution can be cooperatively created.

3.1 The Community of Interest

The community of interest is composed by an heterogeneous set of people. Firstly the citizens, then knowledge engineers, ontology users, and ontology stakeholders. Knowledge engineers are classified as ontology engineers (OE), domain experts (DE), and application experts (AE). OEs are supposed to have skills in semantic technologies (e.g., conceptual modelling and OWL), whereas DEs and AEs are experts, respectively, of the domain of interest (e.g., public transportation) and of the particular application addressed (e.g., management of commuters' trains). Ontology users are the group of people who will operationally interact with ontology-based applications. Ontology stakeholders are people who are interested in the success of the ontology building project (e.g., public administrators and politicians). Finally, there will be representatives of the citizens who need to be informed of the initiatives of the PA and will be the final beneficiaries of the concrete initiatives.

The above mentioned actors in the COI play different roles in the collaborative work. For the ontology evolution process we identify two roles: *ontology owner* and *ontology participant*. The *ontology owner* is the responsible of the overall quality of the ontology content. He/She facilitates the consensus processes, by pushing the harmonization of different points of view. Finally, he/she takes care of the discussion content, periodically summarizes different positions emerging in the debate, identifies the points that can be considered fixed (not to be further discussed), and concludes discussion. The *ontology participant* takes part to consensus activities, like debating and voting.

3.2. How to Reach Consensus

We identified three different activities aimed at reaching consensus in the ontology evolution process: *debating*, *selection*, and *voting*.

Debating. Debating is the process allowing to discuss, share ideas and converge on agreed decisions. To structure this process, we applied a modified version of the speech act theory (SAT) [3]. A speech act is a sentence that an actor utters when interacting with other actors, with a defined intent. Speech act theory mainly concerns sentences that are related to the acts like: proposing, supporting, rejecting, informing, requesting and so on. To properly convey the speech act to the hearer, one possible solution is to "tag" the conversation of the speaker, with a label that can help the hearer to identify what the speaker wants to achieve by his speaking. From the classification of the speech act kinds, we have identified several relevant types to be used in the consensus process. These kinds are: *proposal*, *support*, *concern*, *rebuttal*, *pros*, *cons*, *counterproposal*, *comment*, *revision*, *withdrawal*, *request for information/clarification*, and *mediation*. By using SAT kinds in an explicit form, the communication among people is typically highly-structured and less fuzzy. For example, when someone asks a question, he/she usually expects either an answer or a request for clarification. After a request, a typical response is to fulfill the request or to explain a reason for declining it. We experimented that, in a consensus process, a correct communication structure based on SAT significantly supports the achievement of a consensual outcome.

Selection. Selection is the process of expressing a preference, selecting one among different elements of a list (e.g., terms, definitions of terms).

Voting. Votes are expressed using an ordinal Likert's-like scale [7], widely used to measure attitudes, opinions and preferences. The format of a typical five-level Likert's item is: *strongly disagree*, *disagree*, *neutral*, *agree* and *strongly agree*. These levels are anchored with consecutive integers from 0 to 4. The adopted Likert's item is constituted by a set of levels, with specific format features, related to the topic to be decided.

The responses are combined by adding or averaging the anchored integers in order to produce an overall score.

3.3. Reaching Consensus in the Ontology Evolution Process

In the following, for each SOBE phase, we identify the underlying objective, the involved actors, the specific decisions to be taken, and the related consensus building activity.

3.3.1. Lexicon Validation Phase.

In the first phase, the object of social validation is a set of terms, extracted from a corpus of documents by means of NLP techniques. More precisely, the input of this phase consists of the set of terms belonging to the *E-Lexicon*, and the set of terms belonging to the *O-Lexicon.*

Since, in this phase, social validation concerns the application knowledge, the actors involved in this process are: citizens representatives, application experts, ontology users, and ontology stakeholders.

The objective of this validation process is to eliminate from the *E-Lexicon*:

– extraction errors,
– terms that are out of the scope of the domain of interest of the envisaged ontology.

Consensus is achieved by voting using a scale that expresses the level of acceptance for the terms.

The format of the five-level item is:

(a) strongly agree on acceptance of term;
(b) agree on acceptance of term;
(c) neutral on acceptance of term;
(d) disagree on acceptance of term;
(e) strongly disagree on acceptance of term.

where at each level corresponds a vote, i.e. 4 for level (a), 3 for level (b), 2 for level (c), 1 for level (d) and 0 for level (e). Every actor, involved in the social validation process, assigns a vote to each term by choosing a level of the item.

By choosing level (a), the actor states that he/she strongly agrees in accepting the term as part of the lexicon and assigns to it the vote 4. Level (c), as a choice, means that the actor is not able to decide whether the term should be part of the lexicon or not. This level assigns to the term vote 2. By selecting level (e), an actor expresses strong disagreement on acceptance of the term inside the domain lexicon and assigns to it vote 0.

In the social validation process, every actor chooses a level from the voting scale for each term. If the sum of votes is greater or equal the 60% of the maximum possible score ($4*n$, where n is the number of actors), the term is accepted. Otherwise it is rejected and not included in the lexicon.

All the accepted terms, that are not yet included in the *O-Lexicon*, are gathered in the output lexicon, the *N-Lexicon*.

Input	Terms belonging to the *E-Lexicon* and terms belonging to the *O-Lexicon*
Objective	To eliminate extraction errors and terms that are out of the scope of the envisaged ontology.
Involved Actors	Application experts, citizens, ontology users, and ontology stakeholders
Decision to be taken	Terms to be discarded
Output	*N-Lexicon*
Consensus procedure	Voting

Table 1 Overview of the lexicon validation phase.

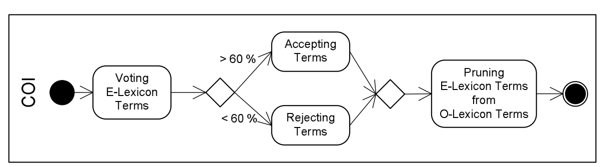

Figure 2 Consensus procedure for phase 1.

The first phase is summarized in table 1, while a sketchy representation of the consensus procedure for this phase is presented in figure 2.

3.3.2. Glossary Validation Phase.

The object of social validation in the phase 2 is the *E-Glossary*, composed by a set of pairs <*term,definitionsList*> (see Appendix) extracted from web resources by means of automated glossary extraction. For each term there is a list of definitions, possibly empty if no definitions are found.

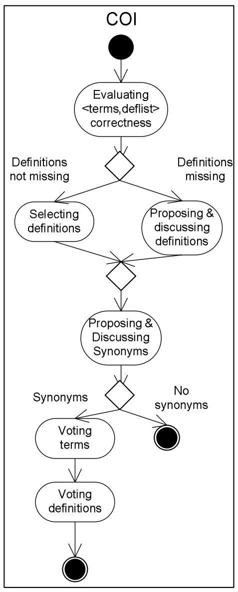

Figure 3 Consensus procedure for phase 2.

Objectives	1) Checking correctness and pruning definitions of the *E-Glossary* to produce validated definitions in the *N-Glossary* *2)* Identification of synonyms, preferred term and preferred definition
Involved Actors	Domain experts
Decision No1 to be taken	Choice of the *E-Glossary* definitions with respect to their correctness
Consensus procedure No 1	Selection, Debate
	Input: *E-Glossary* Output: *E-Glossary* after the correctness pruning
Decision No2 to be taken	2) Selection of candidate terms and definitions after synonym identification
Consensus procedure No2	Debate, Voting
	Input: *E-Glossary* after the correctness pruning, *O-Glossary* Output: *N-Glossary*

Table 2 Glossary Validation Phase.

In this phase, there are two objectives. The first one is to end up with a correct definition, selecting one if several are present, or converging on a new definition if none is present. If one term has no definitions, all the actors are entitled to propose one and then a debate will start to achieve a convergence. If the list of definitions is not empty (at least one definition has been found over the net), the actors select one definition among all or confirm the only one existing. At the end of this activity, the pair composed by one candidate term and one candidate definition is produced, and a debate on possible synonyms of the denoted concept is started. In fact, different pairs <*term,definition*> could denote the same concept (e.g., the pair <*Ontological issue, an issue concerning ontologies*> denotes the same concept as the pair <*Ontological problem, a problem concerning ontologies*>). Social validation is then required to reach the second objective of this phase: to identify synonyms and choose a preferred term and a preferred definition for each set of candidate pairs denoting the same concept. If no synonyms are found, the pair <*term,definition*> is validated as the final glossary entry of the *N-Glossary*. If at least one synonym is found, each actor has to select a preferred term and a preferred definition for the concept in exam.

The selection is carried out by choosing one term and one definition, without the use of scale-based voting. The term and definition receiving the largest number of approvals are chosen as the final glossary entry <*term,definition*>. All the final pairs <*term,definition*> are gathered together to form the *N-Glossary.*

Since social validation in this phase concerns domain knowledge, the involved actors are the domain experts.

A sketchy representation of the consensus process for this phase is presented in figure 3.

The overall phase 2 is summarized in table 2.

3.3.3. Concept Categorization Phase.

In this phase the COI categorizes every glossary entry <*term,definition*> produced in the previous phase by associating a kind to it. The possible kinds are (according to the OPAL ontology framework [6]): *Actor_Kind*, *Object_Kind*, *Process_Kind*, *Complex Attribute_Kind*, *Atomic Attribute_Kind*, *Message_ Kind*, and *Business Object Document_Kind*.

The actors involved in this phase are application experts, domain experts and ontology engineers. The consensus on the categorization of glossary entries is reached by means of the process represented in the figure 4.

For each pair <*term,definition*> of the *N-Glossary*, the involved actors are asked to select one of the possible kinds. The various choices are registered and, if one of the kinds reaches majority, then it is chosen as the concept category. Otherwise a discussion is started in order to debate on the most appropriate categorization for the pair. Once a <*term,definition*> pair is categorized, it becomes an OPAL concept.

A summarization of this phase is presented in table 3.

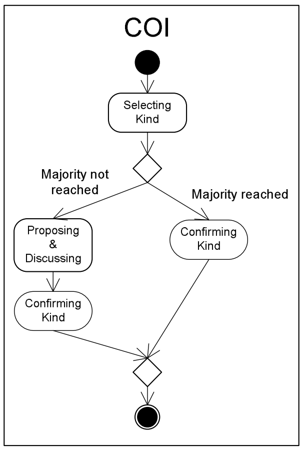

Figure 4 Consensus procedure for phase 3

Input	*N-Glossary*
Objective	Categorize concepts by associating a “kind” (e.g., actor, object, process) to them.
Involved Actors	Application experts, domain experts and ontology engineers
Decision to be taken	Category identification
Consensus procedure	Debating, Selection
Output	OPAL Concepts

Table 3 Concept Categorization Phase.

3.3.4.Taxonomy Validation Phase.

By analyzing the concept’s definitions by means of advanced NLP techniques, it is possible to identify a more general concept for each one in exam. By binding the two concepts with a specialization relation, we obtain a micro-taxonomy (***Eμ-Taxonomy***).

The input of the taxonomy validation phase is constituted by:

1. the set of micro-taxonomies (***Eμ-Taxonomies)***,
2. the taxonomy embedded in the initial ontology (***O-Taxonomy***).

The objective of this validation phase is to insert the ***Eμ-Taxonomies*** in the ***O-Taxonomy***.

The insertion of each micro-taxonomy is based on an algorithm that visits the specialization hierarchy ***O-Taxonomy*** and suggests an insertion point. A full description of the micro-taxonomy insertion algorithm is not reported here since it falls outside of the scope of this paper.

Social validation is required to establish the correctness of the suggested insertion points with respect to the overall *O-Taxonomy*.

The social process is based on a debate where the involved actors are ontology engineers, domain experts, and application experts. For each suggested insertion to be agreed, a discussion is carried out. At the end of this phase, every ***Eμ-Taxonomy*** is placed in ***O-Taxonomy.*** We call this result ***N-Taxonomy***.

This milestone is summarized in table 4.

Input	*Eμ-Taxonomies, O-Taxonomy*
Objective	*Inserting the Eμ-Taxonomies in the O-Taxonomy*
Involved Actors	Ontology engineers, domain experts, and application experts
Decision to be taken	Correctness of the suggested insertion points
Consensus procedure	Debating
Output	*N-Taxonomy*

Table 4 Milestone 4: Taxonomy Validation Phase.

3.3.5 Ontology Enrichment Phase.

The result of the previous phase is a hierarchy where the only type of relation between concepts is specialization. Successively, the hierarchy is enriched with other relationships (such as *PartOf*) in order to obtain a “full-fledged” ontology. Social validation in this phase concerns deciding what type of relationships should be created between which concepts.

The input of this phase consists of the initial ontology and the ***N-Taxonomy***. The social process is based on a debate where the involved actors are ontology engineers, domain experts, and application experts. At the end of this phase, a full new ontology is produced (***N-Ontology*)**.

This milestone is summarized in table 5.

Input	*Initial Ontology, O-Taxonomy*
Objective	Creating a new ontology by enriching *O-Taxonomy* with *Eμ-Taxonomies.*
Involved Actors	Ontology engineers, domain experts, and application experts
Decision to be taken	What type of relationships should be created between which concepts
Consensus procedure	Debating
Output	*N-Ontology*

Table 5 Ontology Enrichment Phase.

4. Case Study: eParticipation Ontology

After being already successfully used in other domains (e.g., enterprise interoperability, eProcurement, project management), the SOBE methodology is currently under experimentation in the eParticipation domain [16] [18]. eParticipation is an ICT-supported participation of citizens in processes involved in public government and governance.

Participation is not only being informed and providing opinions [17]. In a fully-fledged social participation, citizens should be involved in all phases of consultation and options analysis, democratic prioritization of alternatives, decision making, formal deliberations, until budget spending commitment, implementation monitoring, and the final impact assessment of deliberated initiatives.

To reach this goal, innovative ICT solutions should manage an huge amount of knowledge. To this end, an extensive use of public administration ontologies for eParticipation represent a viable option.

The eParticipation ontology models actors (e.g., citizens, public assemblies, and politicians), processes (e.g., social voting), objects (e.g., laws & regulations, city projects), and citizens' needs (e.g., fixing a street or improving transportation). Such an ontology should be built and maintained with a social participative approach, such as the proposed SOBE.

In the following, we briefly introduce some clues obtained in a preliminary experimentation, achieved mainly to test the illustrated process: from the reference documents to the *N-Lexicon,* to the *N-Ontology*. Tables 6 and 7 present an excerpt respectively from the *N-Lexicon* and from the *N-Glossary*. Table 8 shows some OPAL concepts for the eParticipation domain. Finally, figures 5 and 6 illustrate excerpts of the *N-Taxonomy* and the figure 7 and 8 illustrate excerpts of the final *N-Ontology*. These excerpts are presented in UML notation.

N-Lexicon
Citizen, citizens' need, city project, democratic monitoring, defining social priorities, information need, law, local newspaper, media, opinion harvesting, public assembly, public technical office, television, voting, Web 2.0.

Table 6 Excerpt of the *N-Lexicon* on eParticipation

Term	Definition
Citizen	A native or naturalized member of a state or other political community
Citizens' need	Requirement of citizens
City project	A city project is a plan, made or worked out in a city's contest
Democratic monitoring	The process of social monitoring of implementation of planned initiatives
Defining social priority	The democratic process of defining citizens' priorities for public interventions
Information need	Requirement of citizens for a specific information
Law	The collection of rules imposed by authority
Local newspaper	A local publication issued at regular and usually close intervals, esp. daily or weekly, and commonly containing news, comment, features, and advertising.
Media	The means of communication, as television, newspapers, and magazines, that reach or influence people widely
Opinion harvesting	The process of collecting and storing citizens' opinions.
Public assembly	A gathering of citizens who meet in a public facility for open discussions
Public technical office	A public department with technical skills (e.g., environment)
Television	A widely used telecommunication medium for transmitting and receiving moving images usually accompanied by sound.
Voting	A method for a group to collectively make a decision or express an opinion.
Web 2.0	A term used to describe a new generation of Web services and applications with an increasing emphasis on human collaboration.

Table 7 Excerpt of the *N-Glossary* on eParticipation

Actor_Kind (<<BA>>)
Citizen, local newspaper, media, public assembly, public technical office, television, Web 2.0.
Process_Kind (<<Process>>)
Defining social priority, democratic monitoring, opinion harvesting, voting.
Business Object_Kind (<<BO>>)
City project, citizens' need, information need office, law.

Table 8 Excerpt of OPAL concepts concerning eParticipation

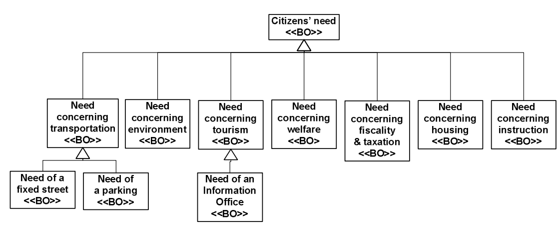

Figure 5 Excerpt of the eParticipation N-Taxonomy: specialization of the "citizens' need" concept

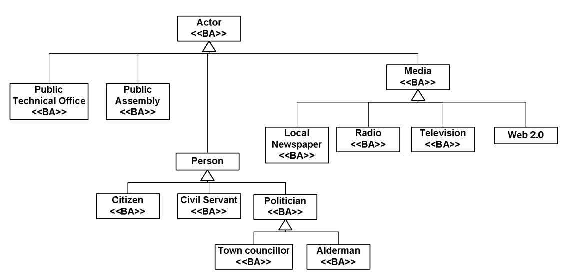

Figure 6 Excerpt of the eParticipation *N-Taxonomy*: specialization of the "actor" concept

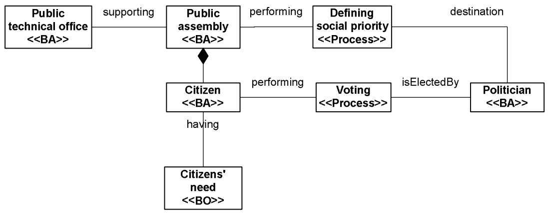

Figure 7 Excerpt of the eParticipation N-Ontology concerning definition of social priorities

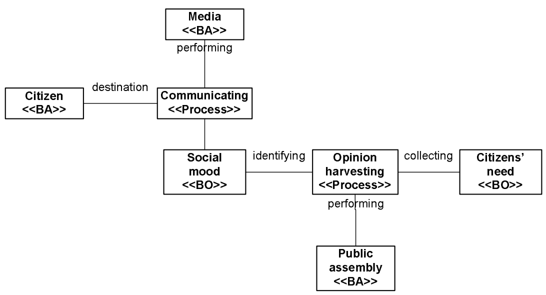

Figure 8 Excerpt of the eParticipation N-Ontology concerning opinion harvesting

5. Related Works

The collaborative approach for ontology building was firstly proposed by [9]. The authors propose to structure collaborative consensus processes using an approach based on the Delphi method [24], i.e. a formal technique for collecting and integrating the views of multiple persons about some topic. The idea is that an initial ontology is critiqued and iteratively revised by participants until they collectively agree on an ontology. With respect to this approach, we focus on a substantial extension and enrichment of an existing ontology rather than on its simple revision.

[10] presents a framework to support ontology evolution in collaborative environments. One of the major contributions of the paper is the classification of scenarios for collaborative ontology evolution and the discussion of the related benefits and weaknesses. In particular, they present: synchronous and asynchronous ontology construction; continuous and periodic archiving of ontology; ontology building with and without a designated curator to resolve conflicts; monitored (i.e., recording the changes) and non-monitored editing of ontology. However, in terms of the overall process, this proposal does not adopt a stepwise method as SOBE does.

[11] proposes to use argumentation theory [13] to support ontology engineering. In particular, the authors present the Diligent argumentation framework consisting of an argumentation process description and an argumentation ontology. The argumentation process is divided in five activities: choosing moderator, choosing decision procedure, specifying issues, and providing arguments and ideas. The last activity is supported by Rhetorical Structure Theory [14]. Then, the argumentation ontology formalizes the argument types that humans tend to use in ontology-engineering discussions (e.g., *issues*, *ideas*, and *arguments*). This approach results too abstract, we propose a greater pragmatism in SOBE.

Finally, another contribution on consensus building techniques applied to ontology engineering is presented by [12]. The proposed methodology includes the definition of the ontology's design criteria, the development of an initial ontology, the iterative process of evaluation and evolution of the ontology according to Nominal Group Technique [15], and the ontology application.

With respect to [9], [10], [11], [12], we present the complete ontology evolution process and we provide a detailed description of the collaborative process (i.e., debating, selection, and voting) and clear indication of the needed steps (i.e., milestones). Furthermore, we introduce in our methodology automatic tools trying to integrate at best human and software-based activities.

6. Conclusions

In this paper we presented a methodology for social participation in the ontology evolution process, aiming to improve the quality of the public administration ontologies. The role of ontologies in eGovernment is steadily growing, and, parallel, the role of citizens in the development of semantic infrastructures need to grow. This is particular true since eGovernment addresses very complex, articulated, and interconnected problems that can be managed only with a federation of different ontologies. We are currently starting a test of the SOBE methodology in the contest of an e-Participation initiative. The first, very preliminary results show that the proposed approach is proceeding along the right direction, making the consensual ontology evolution process more structured, systematic, less error prone, less time consuming, and ensuring better quality of the extended ontology.

7. Appendix

In this Section, in order to better specify the social validation phases, we formally define the taken inputs and produced outputs. This is an updated version of a preliminary set of definitions presented in [1].

Definition 1.
An ***O-Lexicon OL*** is defined as the set of terms labelling concepts of the start ontology.

$$OL = \{Ot_i\},$$

being $i \in N$ and $i \le i_{\max}$

where: $i_{\max} = |OL|$

Definition 2.
An ***E-Lexicon EL*** is defined as the set of terms *EL* automatically extracted from a corpus of reference documents:

$$EL = \{et_i\},$$

being $i \in N$ and $i \le i_{\max}$

where: $i_{\max} = |EL|$

Definition 3.
A ***N-lexicon NL*** is defined as the set of terms belonging to the *EL* and not belonging to the *OL* that have been validated by application and domain experts and ontology stakeholders.

$$NL \subseteq EL,$$

$$NL = \{et_i \in EL \setminus OL \mid approved(et_i)\},$$

being $i \in N$ and $i \le i_{\max}$

where: $i_{\max} = |EL|$

Please note that *approved(x)* is an "human judgment" predicate that is evaluated by a board of experts.

Definition 4.
An ***E-Glossary EG*** is defined as the finite set of terms belonging to the *N-Lexicon NL* paired with the corresponding list of definitions automatically extracted from existing resources. A couple composed by $term_i$ and $defList_i$ is defined as *glossary entry* eg_i of the *E-Glossary*.

$$EG = \{\langle t_i, defList_i\rangle \mid t_i \in NL \wedge defList_i \in DEFLIST\},$$

$eg_i = \langle t_i, defList_i\rangle$ being $i \in N$

$DEFLIST = \{def_i\}$, being $i \in N$

Definition 5.
The ***O-Glossary OG*** is defined as the finite set of terms belonging to a lexicon *OL* paired with the corresponding definitions and validated by domain experts. The couple *term* and *definition* is defined as the *glossary entry* g_i.

$$OG = \{\langle t_i, def_i\rangle \mid t_i \in OL \wedge def_i \in DEF \wedge approved(t_i, def_i)\},$$

$g_i = \langle t_i, def_i\rangle$ being $i \in N$

$DEF = \{def_i\}$, being $i \in N$

Definition 6.
A ***N-Glossary NG*** is defined as the finite set of terms belonging to a lexicon *NL* paired with the corresponding definitions validated by domain experts. The couple *term* and *definition* is defined as the *glossary entry* g_i.

$$NG = \{\langle t_i, def_i\rangle \mid t_i \in NL \wedge def_i \in DEF \wedge approved(t_i, def_i)\},$$

$g_i = \langle t_i, def_i\rangle$ being $i \in N$

$DEF = \{def_i\}$, being $i \in N$

Definition 7.
A concept c_i is defined as a glossary entry g_i categorized by associating a "kind" to it. The "kind" is given by application and domain experts and knowledge engineers.

$$C = \{g_i \mid g_i \in G \wedge kind(g_i)\},$$

$C = \{c_i\}$, being $i \in N$

Definition 8.
An ***Eμ-Taxonomy*** is a specialization hierarchy between two concepts, i.e., the hyponym and the hypernym. It is built using an advanced NLP technique allowing to identify hypernyms from the newly acquired concepts definitions. The **set of *Eμ-Taxonomies*** is defined as:

$$E_\mu T = (C, IsA_{E\mu})$$

$C = \{c_i\}$, being $i \in N$

$IsA_{E\mu} = \{< c_i, c_k >\} \subseteq C \times C$ and $i, k \in N$

where: $IsA_{E\mu} = \{< c_i, c_k > \mid gen(c_i, c_k)\}$
and *gen* is the *generalization* relationship.

Definition 9.
Given a finite set *C* of concepts and a finite set IsA_{OT} of generalization relationships established among concepts, an ***O-Taxonomy OT*** is the taxonomy underlying the start ontology and defined as:

$$OT = (C, IsA_{OT})$$

$$C = \{c_i\}, \text{ being } i \in N$$

$$IsA_{OT} = \{< c_i, c_k >\} \subseteq C \times C \text{ and } i,k \in N$$

where: $IsA_{OT} = \{< c_i, c_k > | \, gen(c_i, c_k)\}$
and *gen* is the *generalization* relationship.

Definition 10.
Given a set of **of** ***Eμ-Taxonomies*** and an ***O-Taxonomy***, a ***N-Taxonomy NT*** is the taxonomy resulting after their merging validated by ontology engineers and domain experts.

$$NT = (C, IsA_{NT})$$

$$C = \{c_i\}, \text{ being } i \in N$$

$$IsA_{NT} = \{< c_i, c_k >\} \subseteq C \times C \text{ and } i,k \in N$$

where:
$IsA_{NT} = \{< c_i, c_k > | \, gen(c_i, c_k) \, | \, approved(gen(c_i, c_k))$
and *gen* is the *generalization* relationship.

Definition 11.
Given a finite set *C* of concepts, a finite set *R* of relationships established among concepts, and a finite set of semantic axioms *Ax*, an ontology *OO* is defined as:

$$OO = (C, R, Ax)$$

$$C = \{c_i\}, \text{ being } i \in N$$

where:
$R = IsA_{OO} \cup De \cup DR = \{< c_i, c_k >\} \subseteq C \times C$
and $i,k \in N$
$Ax = \{boolExp_j\}$, being $j \in N$

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