Knowledge representation through ontologies: an application in the electronic democracy field

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Thanks to their potential to facilitate understanding and assist in the characterization of an interest area, ontologies are widely used as tools for knowledge representation. However, in the electronic democracy context, a systematic review found that this practice needs further exploration. Accordingly, this paper aims to develop an ontology in the electronic democracy field. As a result, we achieved a unique and novel knowledge capture in that domain. Such representation, besides pointing out key domain elements, could aid in the development of electronic democracy initiatives and improve web portals.

Keywords: *Ontologies; Knowledge representation; Electronic democracy; Systematic review.*

Representação do conhecimento por meio de ontologias: uma aplicação no domínio da democracia eletrônica

Graças ao seu potencial de facilitar o entendimento e auxiliar na caracterização de uma área de interesse, as ontologias vêm sendo amplamente utilizadas como ferramentas para representação de conhecimento. Entretanto, no contexto da democracia eletrônica, uma

revisão sistemática comprovou que esta prática vem sendo pouco utilizada. Em função disso, este artigo buscou desenvolver uma ontologia no domínio da democracia eletrônica. Como resultado, tem-se a captura singular do conhecimento sobre o domínio. Tal representação, além de apontar para os elementos-chave do domínio, pode vir a auxiliar no desenvolvimento de iniciativas de democracia eletrônica, bem como no aprimoramento de portais na web.

Palavras-Chave: *Ontologias; Representação de conhecimento; Democracia eletrônica; Revisão Sistemática.*

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1 Introduction

Many works address the electronic democracy theme. These primarily theoretical discussions have been published in several journals with relatively large impact factors.

However, the relation between this theme and ontologies remains underexplored.

In order to validate this claim and investigate the occurrence of studies exploring electronic democracy and ontology, we conducted a systematic literature review including five databases (Scientific Electronic Library Online (Scielo), Elton B. Stephens Company (EBSCO), Scopus, Science Direct and Web of Science (WOS)).

After proving this research gap and using the representations presented in the localized studies as support, we developed an ontology for the electronic democracy field.

Ontologies can be used for knowledge representation within the electronic democracy field to help elicit the key domain elements; they allow for a better understanding of the dynamics of this field, favoring the development of applications and metrics that are able to assist in its measurement and evaluation.

Therefore, in section 2, electronic democracy and related concepts from the literature are presented. Section 3 discusses the theoretical basis for the ontology-development process. In section 4, the methodological procedures that support the development of this article are presented. Section 5 outlines an ontology for the electronic democracy field, detailing the five activities inherent in the construction process. Finally, in section 6, the article's final considerations and opportunities for future work are presented.

2 Electronic democracy

No single definition of electronic democracy[1] is universally accepted in the literature.

To Lemos and Lévy (2010), electronic democracy involves a kind of deepening and generalization of approaches to diversity in a free open spaces of communication and cooperation. For Rover and Mezzaroba (2010), electronic democracy is a tool for a politically dynamic societal improvement, and should be thought from the emergence of the Internet and citizen participation in politics through new technologies.

Garson (2006) argues that electronic democracy is an umbrella term that covers many democratic initiatives offered by electronic means, defined as the use of information and communication technologies (ICT) by the government to improve the efficiency, equity and quality of democratic participation. Most electronic democracy applications include mechanisms to inform, consult and engage citizens in political processes through ICT.

Watson *et al.* (1999) understand that electronic democracy should involve the sharing of political information and opinions between government and citizens. However, it should not be reduced to online polls or the interaction between these actors. The concept's potential is much broader and more fundamental for civil rights and social life (ANTTIROIKO, 2006).

Electronic democracy is usually associated with the use of ICTs to enhance public participation in democratic processes. However, for Grönlund (2002), such purposes have an overly technological focus; electronic democracy must be thought of in terms of its constituent processes and the possibility of institutional innovation. Thus, electronic democracy must facilitate, improve and extend the exercise of democracy through the use of ICTs (CALDOW, 2004).

From this perspective, Shane (2004) believes that the phenomenon of electronic democracy has two distinct meanings: one connected with design and development of ICTs to improve democratic processes and another concerning a new stage of democracy in which ICTs have more vitality and democratic legitimacy, whether at the local, national or global level.

One of the strengths of electronic democracy is its potential to combine a discursive public sphere with the decision-making sphere. In practice, this translates into better-quality information, more direct communication, more transparent administration and a better understanding of public affairs. Even if civic participation in this process is very important, much of this potential can only be realized if governments are actively involved (ANTTIROIKO, 2007).

The establishment of a deepening space for communication and cooperation promotes increased transparency in the political process,

[1] Other terminologies that can be found in the literature are: e-democracy, digital democracy, virtual democracy and even cyberdemocracy.

improves the quality of public information and raises citizens' direct and participatory commitment (SANTOS; BERNARDES; MEZZAROBA, 2009).

Castells (2000) and Gomes (2005) agree that the use of ICTs to raise awareness and promote political participation and citizen involvement can overcome the shortcomings of the current stage of democracy. This process brings with it greater freedom (individual and collective), communication and interdependence (LÉVY, 2003), as it provides citizens with the means to gather their mental strength and create intelligent communities of democracy in real time (LÉVY, 1999).

To Lemos and Lévy (2010), the fates of democracy and cyberspace are closely linked in a way that involves both the freedom of aspiration and the creative power of collective intelligence, two of the most essential aspects of humanity.

It was assumed in this article that electronic democracy reflects the use of ICTs to increase citizen participation in the debates and governmental decisions, allowing an open and transparent government, besides seeking accountability in public administration (SANTOS, 2014).

3 Ontologies

The term *ontology* comes from philosophy, in which it describes the study of existence, a branch of metaphysics aimed at identifying what types of things exist and how they can be described.

For artificial intelligence, what exists is what can be represented. With that thought, Gruber (1993) then states that an ontology, in this area, is an explicit specification of a conceptualization, an abstract model of a real-world phenomenon.

Borst (1997), when analyzing Gruber's definition, found it necessary to emphasize the importance agreeing on the conceptualization that is specified, as such agreement may increase the possibility of ontology reuse. The definition is complemented by saying that an ontology is a formal and explicit specification of a shared conceptualization.

It is precisely this idea of a common shared understanding of a domain that can be interpreted by people and systems that led to ontologies' popularity. An ontology's main motivation is to allow the sharing and reuse of bodies of knowledge in computer form (STUDER; BENJAMINS; FENSEL, 1998). As a result, ontologies are tools to represent, formalize and share knowledge (RAUTENBERG; TODESCO; GAUTHIER, 2009).

An ontology defines a common vocabulary for researchers who need to share information in a domain. This vocabulary includes basic definitions of concepts in the domain and the relationships between them; these definitions are interpretable by machines (NOY; MCGUINNESS, 2001). Thus, they are typically composed of a set of terms representing concepts (hierarchically organized) and some specifications of their meanings (PINTO; MARTINS, 2004).

Ontologies have been applied in several knowledge areas, such as knowledge management, natural language processing, electronic commerce, intelligent information integration, information retrieval, database design and integration, bioinformatics, education and web semantics (SUÁREZ-FIGUEROA *et al.*, 2011).

In building knowledge systems, ontologies play the role of analyzing, modeling and implementing domain knowledge. Because ontologies can capture a common understanding, they can also be used for natural language processing and to enhance the interoperability of heterogeneous information sources. They are also strong candidates to facilitate communication between people and organizations, as they provide the terms, meanings, relationships and constraints inherent in this process. In knowledge engineering, the role of ontologies is to facilitate the construction of domain models (STUDER; BENJAMINS; FENSEL, 1998).

3.1 Types of ontologies

There are different types of ontologies. Although they share the idea of capturing static knowledge about a domain, each type of ontology plays a different role in the process of domain model construction (STUDER; BENJAMINS; FENSEL, 1998).

The types of ontology are (BORST, 1997; STUDER; BENJAMINS; FENSEL, 1998):

> a)Domain Ontology, which formalizes conceptualizations of a particular domain;
>
> b)Generic Ontology, which describes abstract concepts that can be used to define other, more specific concepts in a particular domain;
>
> c)Application Ontology, which describes the dependent concepts of a domain and a particular task, usually due to the combination of domain and method ontologies;
>
> d)Representation Ontology, which provides explanations for the conceptualizations that are the basis of the formalisms of knowledge representation;
>
> e)Method Ontology, which defines how domain knowledge can be used to perform a certain task; and
>
> f)Task Ontology, which expresses conceptualizations about solving problems regardless of the particular domain.

While the first four types of ontologies capture static knowledge independently of the a problem resolution, the latter two focus on the knowledge involved in solving the problem itself; these clarify the

interaction between the problem's resolution and the domain knowledge through the use of restrictions (STUDER; BENJAMINS; FENSEL, 1998).

3.2 Ontology development

Thanks to surveys conducted in the last two decades, the development of ontologies has become a discipline called Ontology Engineering. This discipline is concerned with the set of activities related to the ontology development process: ontologies' life cycles, their methods and methodologies, and the tools and languages that support their construction (PINTO; MARTINS, 2004; SUÁREZ-FIGUEROA *et al.*, 2011).

Different reasons can lead professionals and researchers to develop ontologies. Some of the main reasons, according to Noy and McGuinness (2001), are:

a)To share a common understanding of an information structure among people or software agents;

b)To allow reuse of domain knowledge;

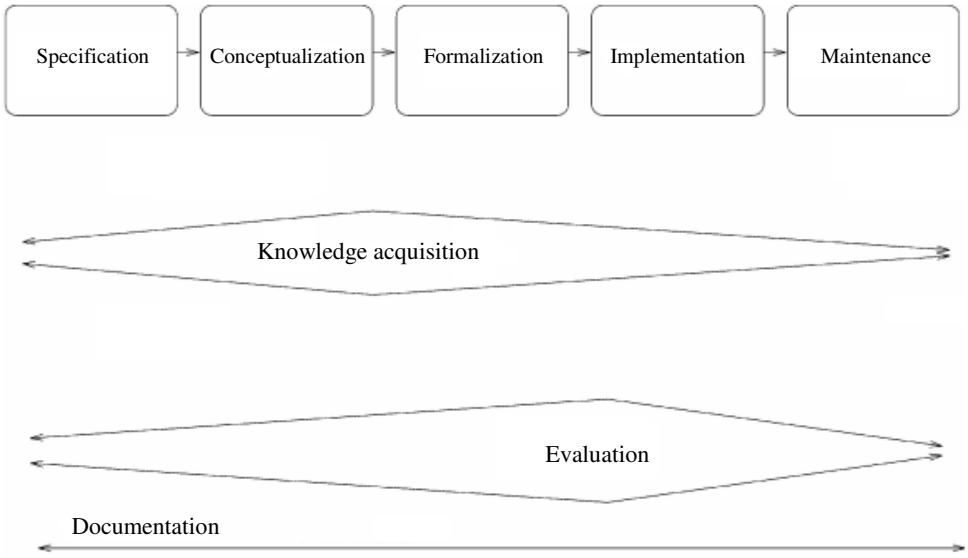
c)To make explicit domain assumptions;

d)To separate the knowledge of the domain from the operational knowledge; and

e)To analyze the knowledge of the domain.

According to Pinto and Martins (2004), the activities inherent in the ontology development process typically include specification, conceptualization, formalization, implementation and maintenance (Figure 1). Depending on the character of the ontology formality, some of these activities cannot occur.

Figure 1 - Activities related to ontology development



Source: PINTO; MARTINS (2004).

In each step, there are tasks to be performed (PINTO; MARTINS, 2004):

a)Specification: identify the ontology's purpose and the scope (the intended use and end users);

b)Conceptualization: describe the ontology in a conceptual model (which contains domain concepts and relationships between concepts) according to the specifications found in the previous stage;

c)Formalization: transform the conceptual description into a formal model (define concepts through axioms that restrict possible interpretations and organize them hierarchically through structural relationships, such as "is-one" or "part-of");

d)Implementation: implement a formalized ontology in a knowledge representation language; and

e)Maintenance: update and correct the implemented ontology.

According to the authors, there are three activities that should continue throughout the ontology development life cycle:

a)Knowledge acquisition: acquire knowledge about the domain using elicitation techniques from expert knowledge (brainstorming, interviews, questionnaires, text analysis and inductive techniques) or the relevant literature;

b)Evaluation: technically judge the quality of the developed ontology; and

c)Documentation: report what was done, how it was done and why it was done. The documentation associated with the terms represented in the ontology is important not only to improve

the ontology's clarity but also to facilitate its maintenance, use and reuse.

According to Noy and McGuinness (2001), there is no right way to develop ontologies. There are some proposals in the literature (NOY; MCGUINNESS, 2001; SURE; STUDER, 2003; GÓMEZ-PÉREZ; FERNÁNDEZ-LÓPEZ; CORCHO, 2004; PINTO; STAAB; TEMPICH, 2004; RAUTENBERG; TODESCO; GAUTHIER, 2009; SUÁREZ-FIGUEROA, 2010), each of which defines a process by which an ontology may be developed.

The choice of methodology is guided by the intuitive, extensible and sustainable nature that it provides for dealing with the ontology's development, which, in practical terms, includes (NOY; MCGUINNESS, 2001):

a)Definition of the classes (concepts in the domain);

b)Organization of the classes in a taxonomic hierarchy;

c)Definition of the classes' properties (internal structures) and values; and

d)Valuation of the properties for instances (elements or individuals in an ontology).

Rautenberg, Todesco and Gauthier (2009) propose an ontology development process that combines the best practices contained in three other methods: *Ontology Development 101* (NOY; MCGUINNESS, 2001), *On-to-Knowledge* (SURE; STUDER, 2003) and *Methontology* (GÓMEZ-PÉREZ; FERNANDEZ-LOPEZ; CORCHO, 2004).

The proposed process is based on five major activities: specification, conceptualization, formalization, implementation and evaluation, each with its own set of specific tasks (RAUTENBERG; TODESCO; GAUTHIER, 2009):

a)Specification: identify the scope and purpose of the ontology, identify its knowledge sources, consider the reuse of ontologies, and generate competency questions that the ontology must answer.

b)Conceptualization: list the ontology terms, add reusable elements, and classify and define the terms.

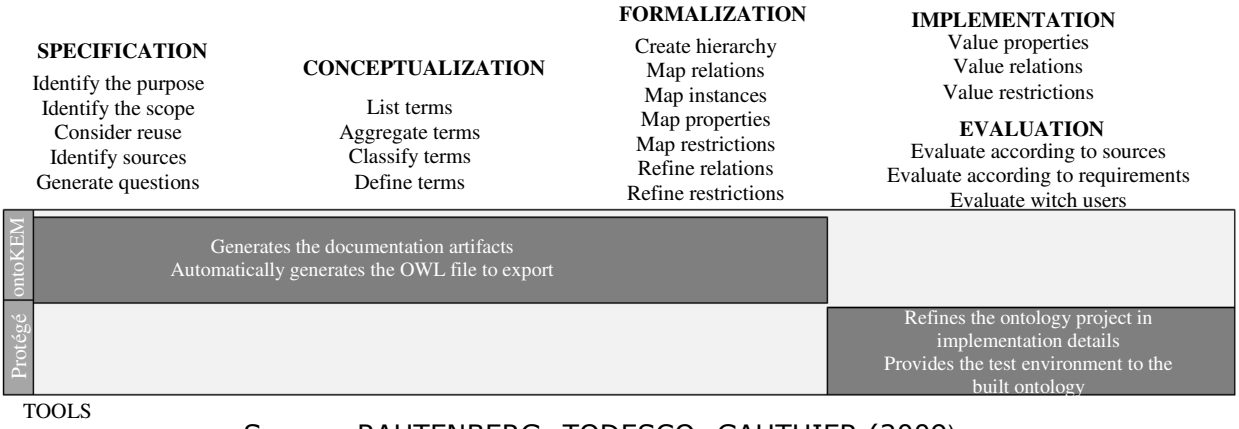
c)Formalization: define the class hierarchy; map the relations, data properties, restrictions and instances to classes; and refine the classes' relations and data properties.

d)Implementation: assess the data properties and the classes' relations and restrictions.

e)Evaluation: evaluate the ontology according to knowledge sources, a frame of reference and the user's vision.

The representation of the proposed process and the authors' suggested tools for each activity are arranged in Figure 2.

Figure 2 - Ontology development process



Source: RAUTENBERG; TODESCO; GAUTHIER (2009).

Despite the benefits that the development of an ontology can bring, it is not an easy task, and it may take some time and require several interactions. Nevertheless, ontologies seem to be a natural choice for those who want to organize knowledge in a given area (SLAVIERO; GARCIA; MACIEL, 2011).

4 Methodological procedures

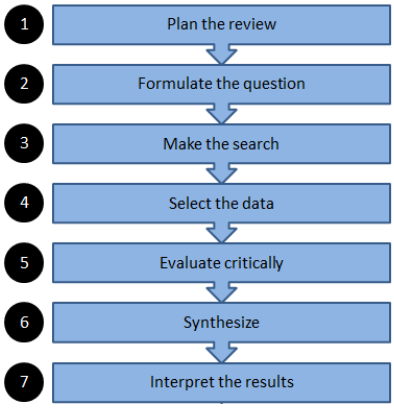
This article used a systematic review to investigate the occurrence of studies on ontologies in the electronic democracy domain. A systematic review is a type of research widely used in health care, and its application can be extended to other knowledge areas. It differs from a traditional (narrative) literature review insofar as it seeks to answer a clearly formulated research question (DE-LA-TORRE-UGARTE-GUANILO; TAKAHASHI; BERTOLOZZI, 2011).

This research method uses the literature on a particular theme as a data source. It provides a summary of evidence related to a specific intervention strategy by applying rigorous scientific search criteria for the selection, critical analysis and synthesis of the selected information. Systematic reviews can identify gaps in evidence in the search field, which aids the future research orientation (CRD, 2001; SAMPAIO; MANCINI, 2007).

Systematic reviews are explicit, methodical, reproducible and updatable. They start from a clearly formulated research question, a search strategy definition, an establishment of inclusion and exclusion criteria and, above all, a careful analysis of the selected literature (SAMPAIO; MANCINI, 2007).

Thus, according to Jackson (2004), a systematic review comprises seven steps (Figure 3).

Figure 3 - Systematic review steps



Source: Adapted from JACKSON (2004).

In the first stage, we plan a systematic review. We choose the databases, define the terms and search fields, and chose the inclusion and exclusion criteria used to select articles (e.g., types of document, language, year of publication).

We choose five databases: Scielo, EBSCO, Scopus, Science Direct and WOS. This choice was made because these databases are recommended by CAPES and because the scope of the multidisciplinary journals in these databases could be interesting to the research subject.

The search terms defined for the survey took into account the intersection of two sets of words: (*electronic democracy* OR *digital democracy* OR *cyberdemocracy* OR *edemocracy OR electronic participation OR eparticipation OR accountability*) AND (*ontology*).

We use some special characters to increase the incidence of works, considering the variations of selected words. These include "*****" (which replaces 0 or more characters; for example, *ontolog** finds *ontology* and *ontologia*) and "**?**" (which replaces a single character anywhere in a word; for example, *c?berdemocrac** finds *cyberdemocracy, ciberdemocracy, cyberdemocracia and ciberdemocracia*).

Thus, the final search term was: (ele?tr?nic* democrac* OR digital democrac* OR c?berdemocrac* OR edemocrac*) OR (ele?tr?nic* participa* OR eparticipa*) OR (accountability) AND (ontolog*).

Given the specificities of each database, the search field selected to verify the occurrence of the terms was established as shown in Table 1:

Table 1 - Search field selected for each database

Database	Search field selected
Scielo	All indexes

EBSCO	All
Scopus	TITLE-ABS-KEY
ScienceDirect	TITLE-ABSTR-KEY
WOS	Topic[2]

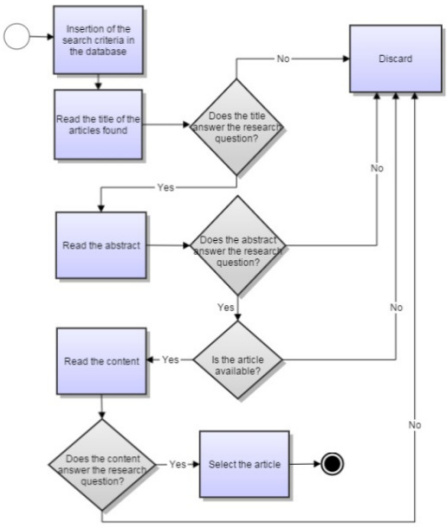
Source: Developed by the authors.

Regarding the document type, we choose articles, reviews and conference papers for inclusion. We limited the searches to works written in English, Spanish and Portuguese. No restriction was assigned regarding the year of publication in order to recover all possible papers published on this issue.

Finally, the article selection process involved reading the title, reading the abstract, check the article's availability in the database and finally, examining the main content. We discarded all works that did not effectively answer the research question.

The design of this process is shown in Figure 4.

Figure 4 - Criteria to select articles



Source: Developed by the authors.

The second stage of systematic review, according to Jackson (2004), involves the research question formulation. Thus, we established the following question as a guide: **What are the relationships explored in the literature between ontologies and electronic democracy**?

The third stage involves performing the search; this research was conducted in the databases according to the pre-established plan between 03 and 14 October 2013. After the search we applied strategies to the databases and 556 articles were returned. After reading the title (RT) and abstract (RA), only 28 articles answered the research question. After removing those that were repeated and those that were not available, 20 articles remained.

[2] The *Topic* field in the WOS database tracks the words in the titles, keywords and abstracts of indexed articles.

After reading the content, four were selected, as shown in Table 2. This fulfilled the fourth stage—selecting the data.

Table 2 - Number of articles per database

Database	Total	After RT and RA	Repeated	Available	Selected
Scielo	-	-	-	-	-
EBSCO	316	13	2	11	3
Scopus	164	9	3	6	1
ScienceDirect	10	1	-	1	-
WOS	66	5	2	2	-
TOTAL	**556**	**28**	**7**	**20**	**4**

Source: Developed by the authors.

The first one (ROSE; STANFORD, 2007) sought to explain the electronic participation dynamics and map the main contributions from the studies in this application area, highlighting the main motivations, supporting technologies, base theories, research methods and actors involved. This paper's major contribution was a scheme to consolidate the core challenges identified in the literature.

The second article (SLAVIERO; GARCIA; MACIEL, 2011), aimed to explore the electronic participation domain in order to identify the best tools to support certain steps of the participation process. To this end, the authors presented a domain ontology featuring key areas, actors, processes, tools, methods and participation levels, and they demonstrated how each of these elements connected to each other and contributed to the dynamics of the research area as a whole.

The third article (AL-SUDAIRY; VASISTA, 2012) presented the state of the art of electronic governance initiatives related to citizen engagement, emphasizing the role of knowledge management in public administration and the role of electronic governance and ICT in the knowledge management and citizen engagement processes.

The last article (DRIGAS; KOUKIANAKIS, 2013) presented an electronic government platform that allowed public access to government information, electronic transactions between government and citizens and management through electronic protocol. Its main contribution was to map a web environment (with the design of the required tools and permission and access levels) to support this dynamic interaction between different actors.

Although the selected articles do not present ontologies for the electronic democracy domain, the representations shown can help in the development of the ontology that is being proposed here.

A relevant aspect to mention is that one of the selected studies referred to two others considered relevant for this study and which also served as a basis for the demonstrated representation (WIMMER, 2007; KALAMPOKIS; TAMBOURIS; TARABANIS, 2008).

4 Ontology in the electronic democracy domain

As previously mentioned, the process of building an ontology consists of specification, conceptualization, formalization, implementation and evaluation, and each step includes a specific set of tasks to be performed.

The design of each step in building an ontology in the electronic democracy domain is shown below.

4.1 Ontology specification

The first activity in building an ontology integrates tasks to identify their scope and purpose; generates competence questions, identifies knowledge sources; and considers the ontologies' reuse (RAUTENBERG; TODESCO; GAUTHIER, 2009).

Scope: The scope of the ontology is to describe the concepts inherent to electronic democracy, allowing better understanding of the domain and knowledge reuse.

Purpose: The ontology's purpose is to point out to the key elements in the electronic democracy domain, allowing a better understanding of the dynamics of this field of study.

Competency questions:

What are the key elements in the electronic democracy domain?

Which elements can be seen on a government portal?

Knowledge sources and reuse:

The use of ontologies in the electronic government field is already well known, especially when assigned to promote interoperable systems, documents and services to citizens (BRUSA; CALIUSCO; CHIOTTI, 2007; PERISTERAS; TARABANIS; GOUDOS, 2009).

However, a survey of scientific databases (demonstrated in the previous section) and a survey of ontology databases (Watson[3] and DAML[4]) revealed little about ontologies in the electronic democracy field.

On the ontology databases, searches were carried out by inserting keywords like *democracy*, *participation* and *accountability.*

In the Watson database, when the search was limited to entities types (classes, properties or individuals), no ontology was found. When the search was expanded to include elements within the entities, some ontologies were recovered; however, none of them were connected to the purposes of the ontology built in this study.

Similarly, in the DAML database, no ontology was found.

One notable aspect of this search of ontology databases was that most of the ontologies available lacked documentation, so details such as exactly what was done, how it was done or why it was done could not be determined in many cases.

A lack of documentation compromises not only the ontology's clarity, but also its maintenance and especially its reuse.

[3] http://watson.kmi.open.ac.uk/WatsonWUI/. Accessed on: October 14th 2013.
[4] http://www.daml.org/ontologies/. Accessed on: October 14th 2013.

4.2 Ontology conceptualization

In order to fulfill the second activity for building an ontology, we listed the terms; added the reusable elements; and classified and defined the terms (RAUTENBERG; TODESCO; GAUTHIER, 2009). These definitions include:

Electronic democracy initiative: an initiative that uses tools to facilitate the engagement of an actor in a specific area in order to promote that actor's participation in a decision-making process or the exercise of social control.

Principles: the values that should be pursued when making an electronic democracy initiative available. Petrauskas (2006) makes the following recommendations:

> a)All (or at least most) of those involved should participate in the decision-making process;
>
> b)There must be interaction and mutual assistance between the actors;
>
> c)All necessary information must be accessible;
>
> d)All benefit obtained must be divided equally between the actors;
>
> e)The decision must be made by consensus and persuasion;
>
> f)After the decision is made, those involved in the decision's implementation are expected to cooperate.

Actor: an external entity who engages with different involvement levels in an electronic democracy initiative. These can be (NCHISE, 2012) citizens, government, private sector entities, NGOs or political parties.

Role: the function an actor performs when involved in an electronic democracy initiative. Roles include *observer* and *participant*, the latter being subdivided by Kalampokis, Tambouris and Tarabanis (2008) into *information provider*, decision maker, *moderator* and *initiator*, as defined below:

> **a)Observer**: an actor who is not registered on the portal and who observes the environment and makes a selection based on his information need. The observer interacts only with information tools on the 'information' engagement level;
>
> **b)Information provider**: an actor who is involved in providing information. This actor may or may not register on the portal, as the 'consultation' level does not always require registration. If the actor engages with the 'active participation' level, a record (or ID) is essential;

c)Decision maker: an actor who is responsible for a decision in a participatory process. This actor is registered on the portal and engages on the 'active participation' level;

d)Moderator / facilitator: an actor who is responsible for maintaining the participation process flow, allowing everyone to have the opportunity to intervene at the right time. This actor is registered and engages on the 'active participation' level;

e)Owner / initiator: an actor who initiates or is responsible for an engagement activity. This actor is registered in the portal and can engage with the 'consultation' or 'active participation' levels.

Engagement level: Several authors identify dimension levels by which a citizen can engage in an initiative (COLEMAN; GØTZE, 2001; OCDE, 2002; MACINTOSH, 2004; IAP2, 2007; WIMMER, 2007; TAMBOURIS et al., 2007). These studies identify three (enables, engages and empowers), four (information, consultation, collaboration and empowerment) or five engagement levels (information, consultation, involvement, collaboration and empowerment). Based on the electronic democracy concept, the most appropriate designation is the one presented by the OECD (2003), namely:

a)Information: At this level, the information (produced and provided by the government) flows essentially in one direction, from the government to the other actors, who access this information according to their needs and interests.

b)Consultation: At this level, a limited two-way relationship between the government and other actors is enabled; the other actors can provide feedback on specific issues the government places on the agenda.

c)Active participation: At this level, an advanced two-way relationship between the government and the other actors is enabled; all actors are actively involved in decision making and public policy formulation.

Engagement area: the specific area in which an electronic democracy initiative is linked within the democratic process. Such areas, according to Tambouris *et al.* (2007) for the electronic participation dimension and Serra, Carvalho and Carneiro (2012) for the social control dimension, comprise:

a)Providing information: use of ICTs to structure, represent and manage information;

b)Collaborative environment: use of ICTs to support training and collaborative environment development;

c)Public consultation: use of ICTs by public or private agencies to enable actors to contribute their views on specific issues;

d)Collective action: use of ICTs to protest, lobby, petition and take other forms of collective action;

e)Election campaign: use of ICTs to support political parties and lobbyists during election campaigns;

f)Deliberation: use of ICTs to support virtual discussions between groups;

g)Discourse: use of ICTs to support analysis and representation through speech;

h)Mediation: use of ICTs to resolve disputes or conflicts in an online context;

i)Territorial planning: use of ICTs for urban planning and environmental impact assessment;

j)Opinion and satisfaction research: use of ICTs to measure opinion and general public sentiment;

k)Voting: use of ICTs to vote in elections, referendums or plebiscites;

l)Account rendering: use of ICTs to support the delivery and rendering of accounts;

m)Open data: use of ICTs to support the dissemination, manipulation and use of open data.

Phase of the decision-making process: A part of the decision-making process based on interpretation of the public policy cycle and understood as a guideline created to address a public problem (SECCHI, 2013). All electronic democracy initiatives that aim for public participation will reach a certain stage of the decision-making process.

While some authors believe that this cycle consists of five phases—agenda setting, policy formulation, decision making, implementation and evaluation (HOWLETT; RAMESH, 1995; SEBRAE, 2008) or agenda setting, analysis, policy making, implementation and monitoring (OECD, 2003) - others define a life cycle of seven stages (SECCHI, 2013):

a)Problem identification: identifying, defining and evaluating a problem to potentially resolve it;

b)Agenda setting: defining which problems should be part of the agenda, according to the attention, resolution and competence required;

c)Alternative formulation: formulating alternatives to solve problems that have become part of the agenda by establishing

goals and strategies and studying potential consequences for each alternative proposal;

d)Decision making: equating actors' interests and explaining the goals and methods for coping with a public problem;

e)Implementation: advancing the rules, routines and social processes from intentions to actions;

f)Evaluation: assessing the proposal's validity for public action;

g)Extinction: eliminating the public policy proposal—only if the problem has been solved, the chosen actions have been perceived as ineffective or the problem has lost importance in the political agenda.

Tools: According to Drigas and Koukianakis (2013), a government portal can offer different tools to actors with whom it relates. Such tools enable different engagement levels and can be classified as information tools or communication tools. Information tools include data about government functions, presentation and performance, and communication tools involve services that enable communication and collaboration between different actors.

In an electronic democracy context, information and communication tools can be used to realize two activities: participation and accountability. While participation equips actors with tools to contribute to common interest issues, accountability allows actors to exercise social control through the requirements for government transparency. Such tools must meet requirements regarding to democracy, usability, accessibility, security and privacy.

Democracy requirements: the requirements that the tools in the portal must meet in order to contribute to the strengthening of democracy. They are (SILVA, 2009): publicity (making the state more visible to citizens), responsiveness (making the state more responsive) and porosity (make the state more open to public opinion).

According to Silva (2009), publicity is primarily concerned with providing information and public content to improve political communication between the state and its citizens. Responsiveness is the state's capacity to respond to a demand generated by citizens. Finally, porosity explores the state's propensity to receive public participation, either through influence or through citizens taking part in decision making.

Usability and accessibility requirements: requirements related to ease of use and access by the greatest number and variety of people, regardless of their physical, perceptual, cultural or social skills.

Security and privacy requirements: requirements that point to features designed to minimize the vulnerability of personal data provided by citizens when transacting with the government through its tools.

4.3 Ontology formalization

Ontology formalization, the third activity of the construction process, we sought to define the classes and subclasses and map the relationships, constraints and data properties.

With the domain term list in hand, we organized the ontology classes and subclasses (Table 3) and added the terms and the relationships between domain classes (Table 4) (RAUTENBERG; TODESCO; GAUTHIER, 2009).

The description of the objects' properties - that is, the relationships between classes - allows for representation of domain knowledge that can be interpreted by machines, which makes the ontology easier to reuse in future applications.

Table 3 – Ontology classes and subclasses

Classes	Subclasses
Engagement area	Providing information, Collaborative environment, Public consultation, Collective action, Election campaign, Deliberation, Discourse, Mediation, Territorial planning, Opinion and satisfaction research, Voting, Account rendering, Open data
Actor	Citizen, Government agency, Private sector entity, NGO, Political party
Phase of the decision-making process	Problem identification, Agenda setting, Alternative formulation, Decision making, Implementation, Evaluation, Extinction
Tool	Information, Communication
Electronic democracy initiative	-
Engagement level	Information, Consultation, Active participation
Role	Observer, Participant (owner/initiator, information provider, moderator/facilitator, decision maker)
Principle	Mutual assistance, Benefit division, Collaboration, Consensus decision, Maximum participation, Availability of information
Requirement	Democratic requirement, Usability and accessibility requirement, Security and privacy requirement
Result	Participation, Accountability

Source: Developed by the authors.

Table 4 – Ontology objects properties

Classes	*Properties*	
	Name	Related Classes
Actor	has level	Engagement level
	has role	Role
	Use	Tool
Tool	Satisfy	Requirement
	Support	Electronic democracy initiative
	enable level	Engagement level
Electronic democracy initiative	Engage	Actor
	has area	Engagement area
	Pursue	Principle
	Aim	Result
Result	Encourage	Phase of the decision-making process

Source: Developed by the authors.

Possible restrictions in the relationships established between ontology classes were evaluated (Table 5), as were the values for the data properties.

Table 5 – Ontology classes restrictions.

Classes	***Properties***	
	Name	**Restriction**
Observer	use	Information tool
	has level	Information
Decision Maker	has level	Active participation
Moderator/facilitator	has level	Active participation
Owner/initiator	has level	Consultation
	has level	Active participation

Source: Developed by the authors.

The data properties connect each class to a specific data type. For the proposed ontology, this means:

a)An observer does not require portal registration.

b)An information provider participant may or may not have portal registration, as the 'consultation' level does not always require registration. If the information provider engages with the 'active participation' level, registration is essential.

c)The decision maker, moderator/facilitator and owner/initiator participants all require portal registration.

d)The 'information' engagement level does not require registration.

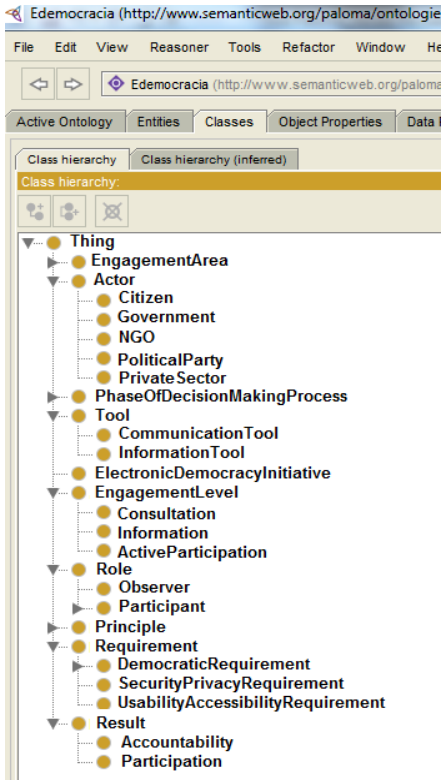
e)The 'active participation' engagement level requires registration.

4.4 Ontology implementation

The fourth activity of the domain ontology construction process involved the implementation of the classes and object properties described above. In order to respect the naming pattern suggested by Gómez-Pérez, Fernández-López and Corcho (2004), the classes were written in the singular, with the first letter of each word capitalized. The object properties were written as verbs, with the first word lowercase and other words capitalized.

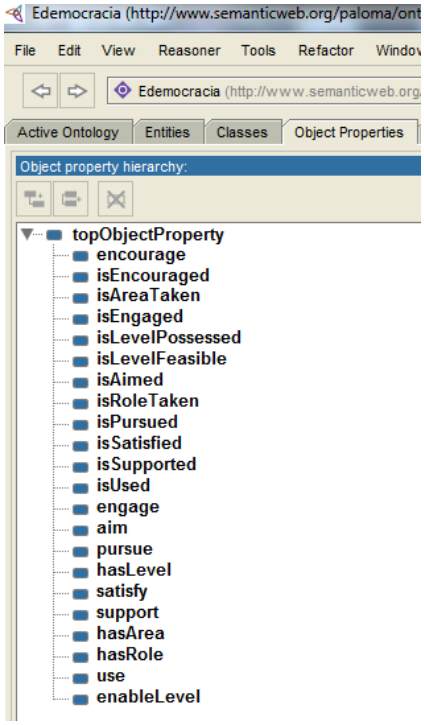
The domain ontology was implemented in Protégé-OWL 4 and Protege-Core Framework (Copyright © University of Manchester 2006, version 4.3.0). Figures 5, 6 and 7 were generated from this process.

Figure 52 – Domain ontology classes



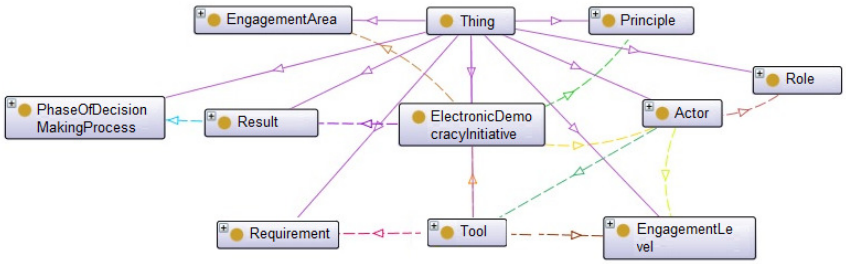
Source: Developed by the authors.

Figure 6 - Object properties of the domain ontology



Source: Developed by the authors.

Figure 73 – Graphical representation of the domain ontology



Source: Developed by the authors.

4.5 Ontology evaluation

In order to meet the fifth and final stage of the ontology construction process, a domain expert and potential users evaluated the ontology.

The expert assessed whether the domain was well enough represented by the concepts and relationships established so that both the ontology's key elements and a formal description of the knowledge area could be identified.

After implementing the changes suggested by the expert, the evaluation process was reinforced when we presented the ontology to potential users in the Legal Data Processing Symposium held in Barcelona, Spain, on 4 and 5 December 2013; the theme of the symposium was "Law, Governance and Technology."

Under the title *Modelo para evaluación de portales de gobierno soportado por ontologías*, the domain representation shown here was made public in order to share its specification and get feedback from potential users. After including the contributions from this process, the evaluation of the domain ontology was considered finished.

During ontology development, both participation and accountability were found to require information and communication tools in order to have a practical effect.

In the case of participation, information tools provide content about an entity's structure and function, which gives citizens the information needed to initiate a rapprochement with the government. Equipped with this information, the actors can interact with the government through communication tools (when establishing contact) and through collaboration tools (when objectifying creativity, information sharing and collaboration).

In the case of accountability, the information required for the control exercise mostly consists of fiscal and administrative data concerning the entity's activity (passive and active transparency); government data are also included. With these, and through control mechanisms (communication tools), a citizen can seek rapprochement in order to monitor and control the implementation of the government's actions or to advance participatory actions.

These information and communication tools must meet basic requirements in usability and accessibility, security and privacy, and democracy. While usability, accessibility, security and privacy requirements are basic aspects of government portals in general, democracy requirements aim to make the state more open to participation, more responsive to citizens' demands and more transparent.

5 Final considerations and future works

Thanks to ontologies' ability to minimize or even eliminate conceptual and terminological confusion among users, facilitating interest-area modeling (NAVIGLI; VELARDI, 2004), ontologies have been widely used to represent knowledge.

According to García Marco *et al.* (2005), when identifying the main elements of a domain, ontology development may assist in indicating dimensions for knowledge area evaluation. Ontologies define which aspects are measurable and amenable to empirical verification.

After the activities of specification, conceptualization, formalization, implementation and evaluation are carried out, this ontology captures unique knowledge in the electronic democracy domain that was not previously found in the literature. The resulting representation allowed for the formalization of terms and relations in the field of study, allowing for a better understanding of its dynamics and its constituent elements.

In addition to pointing out the domain's key elements, the developed ontology can assist in developing electronic democracy initiatives and in improving web portals.

As future work, we suggest using this ontology as a support base for developing such activities.

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