POTENTIAL OF ONTOLOGY FOR INTEROPERABILITY IN E-GOVERNMENT: DISCUSSING INTERNATIONAL INITIATIVES AND THE BRAZILIAN CASE

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Abstract

Interoperability is one of the fundamental requirements to enable electronic government. Its implementation can be classified into technical, syntactic, semantic, and organizational levels. At the semantic level, ontology is regarded as a practical solution to be considered. In this context, its adoption was identified in several countries, with different levels of maturity and so many focuses as the specific implementations. One of the main challenges to be overcome is the legal question that refers to the legislation to assure "the preservation of the legal meaning of data". The lack of efficient mechanisms to support the deployment and use of ontologies can turn the overall task time-expensive, restricted in scope, or even unfeasible. Additionally, many initiatives are recent and need to be validated over time. This paper presents a non-exhaustive survey of the state of interoperability in e-government from the perspective of ontologies' use. The cases of Palestine, European Union, Netherlands, Estonia, and Brazil are discussed.

Keywords: e-Government; Ontology; Interoperability.

Resumo

A interoperabilidade é um dos requisitos essenciais para se viabilizar o governo eletrônico. Sua implementação pode ser classificada nos níveis técnico, sintático, semântico e organizacional. No nível semântico, ontologia é apontada como uma solução prática a ser adotada. Nesse contexto, sua adoção foi identificada em vários países, com diversos níveis de maturidade e diferentes focos nas propostas implementadas. Um dos principais desafios a serem superados refere-se a uma legislação que garanta "a preservação do significado legal dos dados". A falta de mecanismos eficazes para suportar a implementação e utilização de ontologias pode tornar o processo demorado, restrito em escopo ou mesmo inviável. Há também o fator temporal, uma vez que muitas iniciativas são recentes e precisam ser validadas com o tempo. Neste trabalho é apresentado um levantamento do estado da interoperabilidade em e-Gov sob a perspectiva do uso de ontologias. São discutidos os casos da Palestina, União Europeia, Holanda, Estônia e Brasil.

Palavras chave: Governo eletrônico; Ontologia; Interoperabilidade.

1 Introduction

The astonishing advances in Information and Communications Technology (ICT) in the recent decades have been pointed out as the main cause for the revolution our society is experiencing (Castells 2000). However, if the technological advances are in the origin of an Information Society, the concept of Knowledge Society includes social, ethical, and political dimensions. Knowledge Societies are characterized by diversity and the ability to identify, produce, process, transform, disseminate, and use information to build knowledge for the human development (United Nations Educational, Scientific and Cultural Organization 2005).

The Web has transformed not only the traditional way we do business but also has changed the governmental processes, enabling more transparency, participation, and democracy. The electronic government (e-Gov) applies ITC to ease its administration and provide better services to the population, companies, and other state agents. Citizens can be empowered by e-Gov that

enables their active participation in the political processes (Huang et al. 2005).

E-Gov can affect public management in four main areas (United Nations 2005):

1. Internal processes and relationships both through machine automation of routine tasks — especially record keeping and data retrieval—and through enabling much higher levels of communication and collaboration among members of an organization regardless of physical location (the networked "virtual organization");
2. Relations between government and consumers of services and between employers and employees through electronic service delivery;
3. Relations between government and citizens via various forms of digital democracy, including "virtual communities" that facilitate information exchange and political mobilization; and
4. Relations between government and business through taking advantage of "e-business" opportunities in areas such as procurement.

On the other hand, the increasing complexity of information systems, mostly built for dealing with heterogeneity of data and information, makes them hardly able to face the challenge of providing efficient governmental services. So, it is clear the need for interoperability solutions in order to enable the systems integration and the information sharing among the many govern instances (Goldkuhl 2008).

The issue of interoperability, i.e., the ability of two entities mutually exchange and use information, rather than only data, is a common concern and can be approached under different points of view. This question can be understood in terms of four requirements: communication, request generation, data format, and semantics (Guijarro 2007). Kubicek, Cimander and Scholl (2011) identify four levels of interoperability (IOP), as detailed in Table 1 (in appendix).

Luts (2007) lists some factors that can ease semantic interoperability like (i) the increase of data quality, precluding discrepancies among interpretations derived from duplication of data, (ii) less time for integration of information systems of various organizations, (iii) the decreasing in investments for produce and acquire the necessary data.

One way to introduce semantics for interoperability is ontologies (Bishr 1998). From Philosophy, the notion of ontology was assimilated into Computer Science as a shared conceptual framework that aims to formally represent the concepts and their relationships, rules and logical constraints of a given domain. An ontology should be also able be defined by languages readable and processable by computers.

E-Gov is a practical example of using ontologies for interoperability, particularly for dealing with the semantic level (Jarrar et al. 2011; Klischewski 2003; Bettahar et al. 2009; Arendsen et al. 2011). To have an idea about the benefits from using ontologies to ensure interoperability in the context of e-Gov it is relevant to pose the question on how they are being adopted by governments. In this sense, this work provides a non-exhaustive survey of the state of interoperability in e-Gov initiatives from the perspective of ontologies. Publications and technical references were examined to have an acquaintance of the practical applications, having the Brazilian case analyzed closer. We argue that this overview will be important to identify gaps in practical applications of ontologies in the field of government.

This paper is organized as follows. Section 2 presents cases in which ontologies were applied for interoperability in e-Gov. The Brazilian case is discussed in Section 3, including an overview and specific actions implemented or in progress. A comparative analysis is presented in Section 4. Section 5 concludes focusing in the limitations of this study and proposals for future work.

2. Cases for Interoperability and Ontologies in E-Gov

In this section some initiatives that address the application of ontologies as a solution for interoperability within e-Gov are presented. Beyond the Brazilian case, Palestina, European Union, Estonia, and Netherlands were chosen among other alternatives. The Palestinian case is interesting due to the integration problems of a nation with no well-defined territory. European Union deserves our attention by its challenges in integrating many countries, and Estonia and Netherlands as particular cases in which local efforts interrelate with the European project.

2.1 The Palestinian case

In Palestine, the concern was not just automating government processes, but organizing the use of information in such a way that interoperability can be conducted in a safe, legal, and in line with organizational and national policies. That is why Palestine invested in the Zinnar platform (Jarrar et al. 2011). As for the semantic aspects, this platform aims to allow significant processing of data from different information systems, beyond the coordination of different business processes. This approach is justified by the lack, in many government institutions, of a common vocabulary for describing data, business rules, data structure, or standards and classifications. The result is the proliferation of different codes and schemes of names to identify the same entity, in a scenario that encompasses hundreds of databases and information systems.

Zinnar was developed with the participation of several ministries and government institutions, led by the Ministry of Communications, as part of the e-Gov of the country. It acts as a mediator between various semantic

information systems and provide a standard and methodology for new services. As can be seen in Figure 1 (in appendix), there are five basic components, being the ontology placed as the center of the platform.

According to Jarrar, Deik and Faraj (2011), the ontology of Zinnar was designed specifically for applications of e-Gov for the Palestinian Government, including precise definitions of Palestinian Government concepts and their relationships, taking into account laws, decrees, internal organizational, and formal procedures. An example of government service mapped into the Government Ontology is shown in Figure 2 (in appendix). The component "Entities" contains values of mutually agreed of the concept-type value defined in the ontology. Each concept-type value is annotated with the name of the entity component "Entities", which lists the instances of that concept. For example, a concept-type value related to the concept "Natural Person" is the concept of "Country of Birth". Thus, the concept of "Country of Birth" is annotated with the name of the table containing all the countries that represent the values that this concept may have (Jarrar et al. 2011).

The entity "Address" was treated separately as a component of the framework due to its complexity, since until now, there is no unified system for addressing the Palestinian territories. The behavior of other components in relation to the ontology is similar to that exemplified above.

The specification of Zinnar also enabled the mapping of all web services terminology to its ontology (Jarrar et al. 2011). For this, principles of modularization and double articulation, from ontology engineering, were applied (Jarrar 2005). ORM (Object-Role Modeling) (Jarrar 2007) was adopted for modeling. Each module of the ontology consists of three parts: (i) the ORM model, which describes the relevant concepts and their relationships, (ii) the glossary, following the principle of double articulation, and (iii) the business rules.

The proposal presented by Jarrar, Deik and Faraj (2011) is comprehensive and is being implemented in order to, eventually, develop an ontology-based methodology to manage changes and evolution of data and processes, introducing RDFa tags as a concrete step towards Web 3.0.

2.2 The European Union case

The European Union has expended great efforts for the unification of the economies, governments, cultures, and peoples, with consequences in the field of interoperability of e-Gov services (Guijarro 2007; Kubicek, et al. 2011). According to Reichling (2009), beyond the monetary unification, the unification of semantic services to European citizens represents a great challenge. Arendsen et al. (2001) and Laudi (2011) highlight the strength of committees and forums that regulate and drive the development of ontologies and semantic coverage throughout the European Union. In this process, it is worth to pay attention to the performance of SEMIC.EU (Semantic Interoperability Centre Europe), which acts as single point of contact and information for interoperability in Europe. The Center defines rules for the establishment of an open platform for information transmission and represents a tool for collaboration between public administrations of the various member countries.

Laudi (2001) describes the SEMIC.EU as an initiative from the European Commission (EC) implemented with the main objective to improve the semantic interoperability in public administration. This service attracts projects and individuals to share their solutions for semantic interoperability or to integrate them through a joint effort. In 2011, the portals SEMIC and OSOR joined and became the new collaboration platform Joinup (1), which offers various types of integration combined with various value-added services. OSOR is a platform that aims to support the collaborative development of open source applications and solutions.

Among the initiatives of European countries, there are the semantic interoperability initiatives of UK. The UK Government Linked Data initiative uses ontologies to describe the data published as Linked Open Data (2). The British government recommends the use of ontologies and standard definitions for URI creation, and describes the use in area like legislation, health and education (Chief Technology Officer Council 2010).

The team involved in the action "Interoperability Solutions for the Public Administration" (3), from the European Commission, collaborates with the Government Group of the W3C Linked Data (4) to build vocabularies like Core Person Vocabulary, Core Business Vocabulary, and Core Location Vocabulary (5).

Another practical initiative from the European Union, European Interoperability Framework for pan-European e-Government Services (EIF), focuses on national initiatives to complement the Government Interoperability Framework (GIF) existing or in progress in member countries. For this, offers recommendations and standards in general organizational, semantic and technical interoperability, with a set of principles for European cooperation in e-Gov (European Communities 2004).

Concerning semantic interoperability, EIF recommends the adoption of XML as the standard language to exchange information in order to allow the description of the meaning and structure of data. However, only the adoption of this standard language does not guarantee the semantic interoperability. It is achieved by means of initiatives that develop the necessary definitions, with the subsequent introduction of XML schemas and

other artifacts related, as ontologies. This set will allow the integration of services that were developed with different vocabularies and different perspectives on the data. However, this guide does not provide more details on the use of ontologies as possible patterns, tools and practical examples.

2.3 The Netherlands case

Following the trend of other governments, the Dutch government created a two-way interoperability policy involving both enterprises and citizens. Arendsen, Zwienink and Luttighuis (2011) discussed how the Dutch government came to the e-Gov with interoperability. This effort included governance, standardization, and transparency issues.

The authors described the new plan of action named Netherlands in Open Connection and the creation of the Council of Standardization. It is also presented an interoperability agenda detailing the four items of highest priority: open standards, systems interoperability, services governance, and semantic interoperability.

The Dutch Government Reference Architecture (NORA) is the main reference of e-Gov architecture in the Netherlands. According to ICTU (2007), the fundamental principles are based on a set of criteria for citizens, businesses, and the government, beyond the guidelines provided by EIF.

NORA provides that semantic models should be created as: vocabularies, taxonomies, object models, and ontologies. The main differences among these models can be observed in the structures they can express and how each one can work with static and dynamic concepts.

NORA establishes a set of principles about semantic interoperability as: (i) communication patterns should be associated with a semantic model, (ii) semantic models should be technology-neutral, (iii) the appropriate size of a semantic model should be customizable. These rules along with the fact that "an ontology is not necessary in the beginning" for service registration, shows that the use of ontologies plays a secondary role in the operationalization of the Dutch e-Gov.

2.4 The Estonian case

The Interoperability Framework of the State Information System platform, launched in 2004, is the Estonian solution for e-Gov interoperability. It includes a set of rules and standards that ensure the offer of public services to citizens, businesses, and public institutions, at national and European levels, following the EIF recommendations (Vallner 2006).

This framework encompasses the legal, technical, semantic, and organizational dimensions. The legal dimension refers to services, data, and information systems security under the legal point of view (Estonia 2011). The technical, semantic, organizational dimensions are similar to those defined by Kubicek, Cimander and Scholl (2011).

According Vallner (2006), to achieve semantic interoperability, organizational, social and educational efforts are needed. Only the establishment of requirements and standards for all systems is not enough. It is also necessary to facilitate the work of software engineers and developers. For this, solid documentation about data structures and protocols should be provided, as well tools, languages, dictionaries, classifications, and rules that can lead to robust ontologies.

The author argues that the assets of syntactic interoperability as XML schemas, metadata schemas, and core components are the first level to achieve semantic interoperability. In its turn, semantic interoperability assumes the existence of dictionaries, taxonomies, tables, maps, ontologies, and services registries.

Within this scenario, the Estonian government has published two documents that deal specifically (Luts 2007). The first provides instructions for the semantic description of databases and the operations performed by databases, and includes information and rules for developers, companies, and auditors (Estonia 2007a). The second approaches a methodology for semantic interoperability of databases and operations performed by databases (Estonia 2007b).

The main component of this architecture is the Administration System for the State Information System (RIHA). The ontologies and metadata are published and hosted in RIHA. According the Interoperability Framework of the State Information System, each owner of an information asset publishes in RIHA the semantic descriptions of this asset. Moreover, semantic and annotated information assets must be also published in RIHA according to the requirements of the semantic guideline.

The components of the architecture of semantic interoperability, as shown in Figure 3 (in appendix), are: (i) Glossary of domain - core description of the semantics of data elements and operations, written in OWL, (ii) Semantic description of databases and operations (written in WSDL, WSDL-AS, etc.) - includes a description of each database and its components and, if available, a reference to its entry in the glossary of the domain.

The Estonian case differs from others not only because interoperability was implemented after the deployment of e-Gov (i.e., there was already operating services), but rather because a specific framework for interoperability was adopted.

3. The Brazilian case

The Brazilian e-Gov program aims to democratize access to information, stimulate discussion and broaden the offer of public services with efficiency and effectiveness with respect to the govern role (6).

The enormous complexity involved in the semantic context of interoperability for Brazilian e-Gov is related to the natural difficulty of concept interpretation caused by ambiguities, inconsistencies, and other semantic problems. This complexity is also positively affected by the number of agents involved. The Federative Republic of Brazil includes 27 states, more than 5,560 municipalities, and 196 organizational structures in the Federal Administration (7), that are autonomous for contract and develop software and networks. Besides these govern agents, it is clear the necessity of society participation in the construction and use of vocabularies and ontologies that allow the practical implementation of interoperability.

3.1 Interoperability Standards for the Brazilian e-Gov: e-PING architecture

The coordinated actions of many govern entities led to the arising of the main reference on e-Gov interoperability in Brazil: e-PING (Interoperability Standards for Electronic Government) architecture. This architecture considers that interoperability involves technical, organizational and semantic issues, and defines general policies for each of these dimensions.

From a technical point of view, the alignment of public administration information systems with the main specifications used on the Internet and the WWW is pursued. The aiming is to make all government information systems accessible by means of the available technologies, taking into account the security level required by the service, and aspects of scalability.

In the organizational context, e-PING aims: (i) to simplify the public administration, contributing to keep simple and straightforward the government's interactions with society, (ii) promote collaboration among organizations by integrating corporate objectives and business processes of organizations with different internal structures and internal processes and (iii) ensure the privacy of citizen information, companies and government agencies, respecting and complying with legislation defining the restrictions on access and disclosure.

As a dimension of e-PING, the semantic interoperability aims to ensure that the interchanged data have their meaning correctly interpreted in the context of a given transaction, or a search for information, considering the culture, conventions and terminology adopted by each industry or company. In order to guide the development of ITC solutions adherent to e-PING architecture, it was edited the Government Interoperability Guide (8).

Still considering the semantic dimension, the e-PING establishes guidelines for development and maintenance of ontologies and other resources for information organization such as controlled vocabularies, taxonomies, and other methods for organizing and retrieving information, which results should be shared, reused, and available in a repository of vocabularies, and ontologies. In this sense, the Repository of Vocabularies and Ontologies of the Electronic Government (e-VoG), organization that keeps all ontological references, was implemented. In addition to the role as persistent repository of reference ontologies in e-Ping, e-VoG is responsible for: (i) training in ontologies, (ii) the provision of a set of vocabularies and domain ontologies, (iii) the availability of a good practices guide and an ontology engineering process, and (iv) the establishment and monitoring of a policy for URIs to publish data in the government.

The e-PING documentation specify how the information are formed, validated, processed, represented, described, and classified in order to meet basic requirements for semantic interoperability. It refers to the following segments of e-PING: (i) interconnection, (ii) access means, (iii) organization and exchange of information, and (iv) integration areas for e-Gov.

Unlike the Palestinian case that adopted ontologies as a central part of its interoperability framework, Brazil adopted ontologies with a decentralized approach. Moreover, the ontologies are built and incorporated as they are required.

Among the initiatives to ease semantic interoperability in the Brazilian government it is worthwhile to notice: the National Infrastructure Open Data (9), Controlled Vocabulary of Electronic Government (10), and National Spatial Data Infrastructure (11). INDA has a prominent role in the: (i) coordination of the Brazilian efforts in training on ontologies, (ii) analysis of management tools and publishing ontologies and (iii) publication of guidelines for establishing URIs.

INDA maintains the Brazil Open Data portal (12) that appraises the main core technologies for building ontologies like: (i) OWL, (ii) FOAF (ontology describing data, activities and relationships between people), (iii) schemas, and (iv) RDF. However, it cannot be considered a normative case for the use of ontologies, since it does not address important issues such as the participation of society and the engineering processes of ontologies.

VCGE is available as a scheme to be used under the Electronic Government Metadata Standard (e-PMG), and can be used in web pages and RDF documents. Terms from VCGE makes straightforward the presentation of services available by means of a directory

structure based on its indexes. The public agencies may suggest the inclusion of new terms in the vocabulary, beyond being allowed to make the equivalence of a global terminology VGCE with their local terminology.

Another case study on ontology application is related to interoperability in geo-technologies realm, legally supported by a legislation that defines the National Spatial Data Infrastructure (NSDI). Its objective is to ease and organize the generation, storage, access, sharing, dissemination, and use of geospatial data in all levels of govern. According the Federal Geographic Data Committee, the goal of this infrastructure is to reduce duplication of effort among agencies, improve quality and reduce costs related to geographic information, to make geographic data more accessible to the public, to increase the benefits of using available data, and to establish key partnerships with states, counties, cities, tribal nations, academia and the private sector to increase data availability.

3.2 The Experience of the Federal Budget Secretariat

Given the general guidelines established by the government with regard to semantic interoperability, several federal agencies have invested in the construction of ontologies and opening data, under the Linked Open Data perspective. Among the first successful experiences involving governmental agencies there is the one promoted by the Federal Budget Secretariat (Secretaria de Orçamento Federal – SOF), considered relevant by having pushed other government agencies to make investments in semantic interoperability.

SOF is the Brazilian office for budget management. The realization of the duties of the SOF depends on updated and comprehensive information about different topics related to the federal budget. This information is distributed in the vast budget legislation, documentation generated by SOF and other offices, and various structural systems of the federal government, especially the Integrated Planning and Government Budget (SIOP) (13). Given the wide scope of the public budget, there is no consensus on the interpretation of the many budgetary concepts used in all spheres of government. This misalignment, however small, negatively impacts the discussions on the allocation of public resources.

Due to the mentioned reasons, SOF engaged in the construction of ontology for public budget, aiming: (i) improve the semantic expressiveness of the current indexing language, (ii) ensure a conceptual agreement on the federal level, replicable to other levels of government, (iii) create a context to expand the interoperability of information systems of SOF, and (iv) meet the interoperability standards recommended by the Federal Government.

Due to the problem complexity and the limited experience in the construction of ontologies in the context of the Federal Government, it was decided to develop the work step by step, starting with a basic ontology concepts, covering only the most consensual expenditure items (although not unanimous) on the public budget (Araújo et al 2012). Figure 4 (in appendix) reflects the result of this effort considering only the expense items and its budgetary classifiers (Function, Subfunction, program, and so on). In this figure, the identified concepts is described as OWL classes and are identified by rectangles in gray and the relationships between classes' elements by black rectangles. The range of the relationship is represented by a letter r, while the domain is represented by the letter d. Dashed lines represent subclass relationships. The prefix siop was assumed for the object properties while the properties of data types are represented by white rectangles containing its type. As a result of this investment, SOF made available its annual budget data (from 2000) in open format (RDF) with a conceptual agreement assured by the definitions from the built ontology.

The pioneering experience of SOF inspired several other initiatives such as: (i) the collaborative construction of an Ontology for Social Participation (OPS) (14), (ii) the Organization of Geospatial Vectorial Data (EDGV) (15), from the National Committee of Cartography (CONCAR), (iii) the Integrated System for Financial Administration (SIAFI) (16), (iv) the Unified Record of Suppliers (SICAF) (17), and (v) the System of Offices and Organization Structure (SIORG) (18).

4. Comparative analysis

Different emphases were observed in the set of initiatives studied. In order to discuss the features that most characterize the cases, we choose to analyze them under a three-layer structure, adapted from Kubicek, Cimander and Scholl (2011). As shown in Table 1 (in appendix), this structure encompasses the data, systems, and semantic interoperability. The data interoperability layer refers to: (i) existence of a standard data representation, (ii) metadata transportation and (iii) data integration. The systems layer includes mainly concerns on interconnection of services. The semantic layer focuses on the ability to enable a fully comprehension of contents and the possibility of understanding multiple representations of concepts. Beyond the comparison on the basis of the use of ontologies for each interoperability level, the discussion includes also other relevant features (See Table 2, in appendix).

In the Palestinian case the motivation for a robust e-Gov system arises with a clear intention to structure the complex interrelation of Palestinian people, spreaded around the world, and its representative entities.

The high level of expectations from European Union (Commission of the European Communities 2003) has led to an emphasis in standardization, infrastructure, and collaboration, adopting ontologies to face the se-

mantic challenges. However, local priorities can be observed, as is the cases of Estonia and Netherlands. Estonian initiative can be seen as a case of an evolution from an e-Gov in which interoperability was not a priority to its alignment to the European model. Additionally, although having a proposal for e-Gov interoperability, Netherlands does not give ontologies a priority place.

The Brazilian government, by means of the Secretariat for Logistics and Information Technology, from the Ministry of Planning, Budget and Management, is commited in promoting semantic interoperability in e-Gov. However, the lack public policies for defining standards in this context, is delaying its wide adoption.

5. Conclusions

Despite being recognized, the role of ontology as a potential solution for semantic interoperability in e-Gov is not yet an alternative consolidated. This study showed that this approach is recommended and ontologies can play an important role for achieving semantic interoperability. However, except for the case of Palestine and Estonia, it was not possible to identify in detail the practical implementation of this use. Thus, there is a gap for empirical studies that can indicate potential barriers and advantages of this form of practical application of ontologies.

The Estonian case provides the best evidence on how to implement and use ontologies for semantic interoperability in e-Gov, since emphasize the importance of syntactic interoperability and organizational efforts, educational and social (Vallner 2006).

As future studies, it is suggested to research models for developing ontologies centered on e-Gov in which the knowledge, in this area, can be disseminated in practical applications.

Notes

(1) http://joinup.ec.europa.eu (2015).

(2) http://data.gov.uk/linked-data (2015).

(3) http://ec.europa.eu/isa (2015).

(4) http://www.w3.org/2011/gld/wiki/Main_Page (2015).

(5) http://joinup.ec.europa.eu/asset/all (2015).

(6) http://www.governoeletronico.gov.br/o-gov.br (2015).

(7) http://www.governoeletronico.gov.br/acoes-e-projetos/novo-siorg (2015).

(8) http://www.governoeletronico.gov.br/acoes-e-projetos/e-ping-padroes-de-interoperabilidade (2015).

(9) http://www.governoeletronico.gov.br/acoes-e-projetos/Dados-Abertos/inda-infraestrutura-nacional-de-dados-abertos (2015).

(10) http://vocab.e.gov.br/id/governo (2015).

(11) https://www.fgdc.gov/nsdi/nsdi.html (2015).

(12) www.dados.gov.br (2015).

(13) https://www.siop.planejamento.gov.br (2015).

(14) http://vocab.e.gov.br/2013/12/ops (2015).

(15) http://vocab.e.gov.br/edgv/2.1. (2015).

(16) http://vocab.e.gov.br/siafi (2015).

(17) http://vocab.e.gov.br/sicaf (2015).

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Apendix

Layer IOP	*Aim*	*Object*	*Solution*
Technique	Technically ensure secure data transfer	Signals	Data transfer protocols
Syntactic	Processing of the data received	Data	Standardized formats of data exchange. Example: XML
Semantic	Processing and interpretation of data received	Information	Common directories, data keys, ontologies
Organizational	Automatic connection process	Process (workflow)	Architectural models, standardized processes

Table 1. *Levels of interoperability* (Kubicek, Cimander and Scholl 2011)

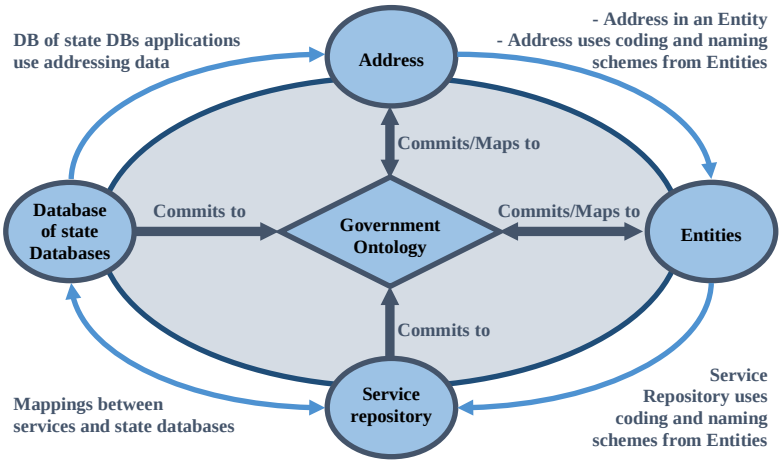

Figure 1. *Zinnar platform reference model* (Jarrar, Deik, Faraj 2011)

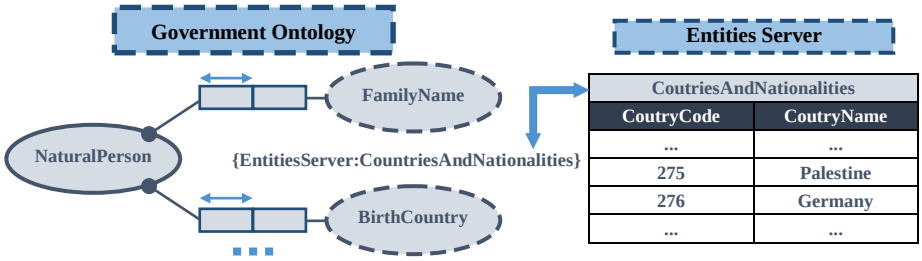

Figure 2. *Part of the relationship between ontology and Governmental Entities* (Jarrar, Deik, Faraj 2011)

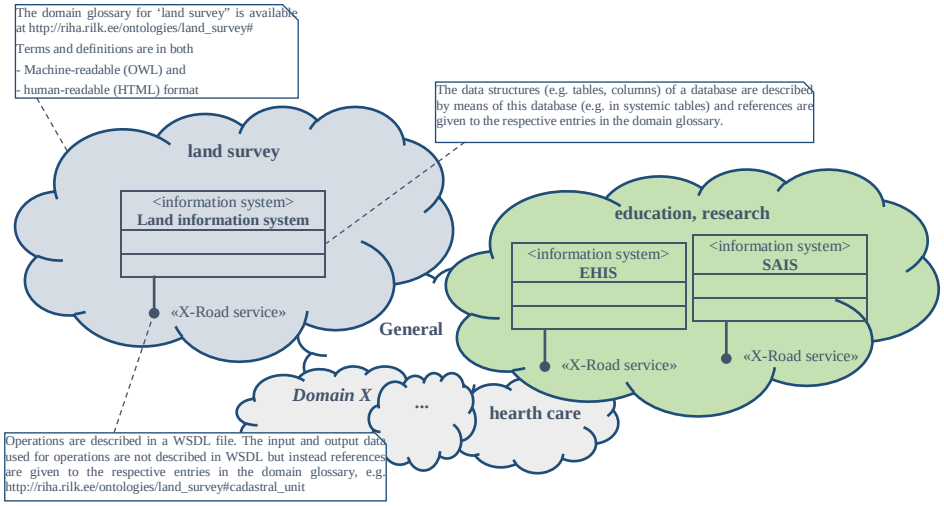

Figure 3. *Components of the Semantic Architecture* (Estonia 2007)

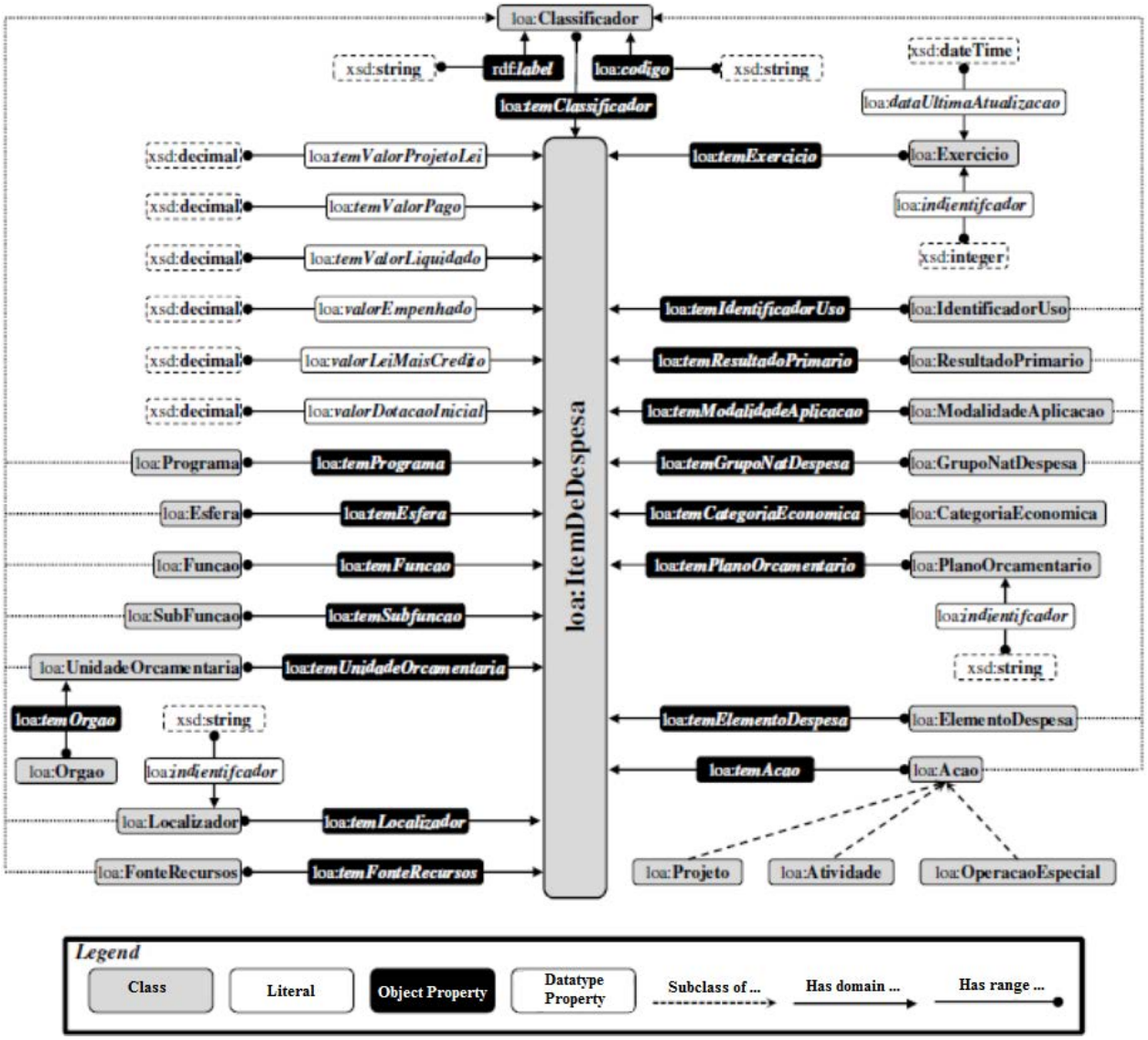

Figure 4: Basic ontology of expenses items from the federal public budget (Adapted from the ontological model from the Expenses Classification of Brazilian Federal Budget - http://vocab.e.gov.br/2013/09/loa)

Ontology for …	*Country* [Project]				
	Palestine [ZINNAR]	*European Union* [SEMIC.EU and EIF]	*Netherlands* [NORA]	*Estonia* [RIHA]	*Brazil* [e-PING]
Data interoperability	•	•		•	•
Systems interoperability	•	•		•	•
Semantic interoperability		•		•	•

Table 2. *Uses of ontologies for each level of interoperability*