Ontology-Based Model of E-Governance

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Abstract

This work presents development of ontology-based model of e-Governance, which would be useful for knowledge structuring, standardization and sharing among experts and software engineers who create applications in this area. The main goal is e-Governance semantic harmonization with terminological and technical standards used in society and the public network Internet. For that reason a comparative analysis of e-Governance vs. e-Government is implemented to introduce the reader to the e-Governance ontologies state-of-the-art. The hierarchical ontological model of e-Governance can be considered as extension of existing e-Government model. It includes meta-ontology of e-Society, e-Governance domain ontology and set of application and task ontologies.
As examples case study assets are proposed exploring the concrete services provided of the Bulgarian National Employment Agency (NEA).

Keywords: e-Governance, e-Government, e-Society, domain ontology, application ontology, task ontology, e-service

Introduction

The utilization of information and communication technologies (ICT) for democratic administrative governance (so called e-Governance) is one of the most important activities in the modern society. The structure, content, objectives and problems of e-Governance are discussed several decades but there are many uncertainties in its description. Largely this is due to the insufficient terminology standardization as well as to different knowledge level of specialists dealing with development and support of e-Governance functions. In the last years different efforts of establishing e-Government standard (the one of the main parts of e-Governance) are produced. Some of them are tied with the most disseminated Dublin Core metadata standard [34]. The research of OASIS Technical Committee [6] asserts that "the main thrust nowadays is to adopt open, international standards, including the Internet and World Wide Web specifications, for all government systems".

We claim that data integration, full and detailed e-Governance services description only by ontology development and utilisation is possible because by [1]:

> "the inability of existing integration strategies to organize and apply the available knowledge to the range of real scientific and business issues is impacting on not only productivity but also transparency of information on crucial safety and regulatory applications. The new range of semantic technologies based on ontology enables the proper integration of knowledge in a way that is reusable by several applications across the governance or businesses from discovery to corporate affairs".

Nature of e-Governance

The main categorizations of knowledge found within the e-Governance domain is the space where public administrations and their systems meet citizens and businesses during service provision and interaction, take in mind the form, origin and characteristics of the knowledge to be modeled [9]. In this context some embarrassment exists between concepts *government* and *governance*. The important distinction is that *government* is the institution itself, whereas *governance* is a broader concept and describes the way in which an organization chooses to engage in certain activities backed by goals shared by its constituents [8]. Therefore, e-Governance as more extensive concept includes e-Government. As stated in [19] "most broadly, concept of e-Governance will cover government, citizens' participation, political parties and organizations, parliament and judiciary functions" or in other words – e-Government and e-Democracy.

The electronic services (e-services) between political organizations (POs), elected officials (parliament, elected local communities, judiciary etc.) and citizens are part of e-Democracy. On the other hand, e-Governance is a part of e-Society. By [16] e-Society comprises ICT services of civil institutions (private sector service providers, non-profit and community organizations) and citizens. It is externally linked with ICT services of public agencies and other governmental institutions. By [19]:

"The e-Society can be broadly defined as one that uses digital media in most relationships: peer-to-peer (personal communications, business-to-business (B2B), purchases etc.); government-to-other (government online); other-to-government (voting/governance); peer-to-other (business-to-consumer (B2C) etc.)".

Combining these two near views, by our opinion e-Society (or digital public service) as structure includes e-services between government, political organizations,

elected officials, citizens, business and non-political non-governmental organizations (NPNGOs). Then, e-Governance as a part of e-Society comprises the e-services concerning e-Government (other-to-government, government-to-other) and e-Democracy.

E-Governance ontologies state-of-the-art

The advanced design and/or modeling of any system or process are preceded by conceptualization, i.e. extraction of the main concepts in the respective domain. This activity is accompanied by revealing of commonly accepted concept definitions, synonyms, hierarchical and non-hierarchical relations, links with another related domains, translation in different languages, etc. On the other hand, conceptualization is the first stage of domain ontology development.

It is well-known that application of ontologies in analytical modeling increases efficiency and quality of the models with a view of its subsequent search and/or analysis. Moreover, without building ontology now a lot of problems due to terminology inconsistency and missing data integration arise.

After a detailed state-of-the-art analysis we concluded that the number of ontologies in the area of e-Governance (particularly in e-Government) increases continuously. For example, within FP6–507483 EU-funded project [33] three ontologies (about geographical information system (GIS), time/space and meteorology) are developed. Besides these, in the "DAML free ontology library" [10] there are two ontologies which refer to governmental concepts: a) Government R&D [25], which describes organizations and individuals participating in a government research and development program made in 2000; and b) Government type [23] which describes government concepts used in World FactBook of the Central Intelligence Agency (CIA) about British governmental organization.

Appropriate works considering mostly the legal domain of e-Governance are:

- Estrella Legal Knowledge Interchange Format for e-Government Ontology [24];
- LEXIS ontology for Legal Framework Modeling [20] concerning modeling and representation of legal elements (directives, laws, decrees) of national parliaments of some European countries;
- XML repository for legal resources [21, 25, 26];
- Ontologies for comparing and harmonizing legislation [4, 32] etc.

Other works [2, 12, 13, 19] refer to configuring e-Government services to ensure effective retrieval of large amounts of information during semantic search in real world scenarios. In [27] Governance Enterprise Architecture (GEA) is developed which aims to create top-level domain ontologies for overall governance system and e-Government public services in different European countries. Own ontology-based modeling of Italian Local Public Administration (LPA) services in [29,3] is described. Under this project (called Arianna) more of 250 UML[1] ontologies distributed in seven groups and organised in particular repository are created.

The largest project in the area of ontology-based model of e-Governance is oeGOV initiative of US company TopQuadrant Inc. [17]. It comprises three sets of ontologies:

- Government Structure ontologies;
- FEA (Federal Enterprise Architecture) ontologies;
- QUDT (Quantities, Units, Dimensions and Types) ontologies.

Each oeGOV ontology is represented by OWL schema and dataset published as .n3 file (called "named graph"). The main goal of the oeGOV is to create overall model of government as a base for developing concrete country government models. Under oeGOV a set of ontologies for US e-Government structure and services is built.

In recent years SEMantic Interoperability Centre [30] of European Commission was created as a platform and a service initiated in the framework of IDABC (Interoperable Delivery of European e-Government Services to public Administrations, Businesses and Citizens) program and extended by ISA (Interoperability Solutions for European Public Administrations) program. According to SEMIC, sector-specific sets of data structures and data elements should be created called semantic interoperability assets2. Once these are created, the cooperating organizations will need to agree on the meaning of the information to be exchanged.

Having in mind the above results, we decide to provide a common ontological model of e-Governance as extension of existing e-Government models and to propose further knowledge structuring, standardization and sharing among experts and software engineers who develop applications in this area. Another ambition of this work is design, building and dissemination of application and task ontologies as exemplary assets or instances of e-Governance domain ontology. A holistic approach towards domain concepts organizing, sharing and disseminating is applied, intended to better understanding its matter.

The paper is structured in four main sections. The next section examines the ontology schema of the e-Governance model. The third section describes the process of creation of e-Governance domain ontology. In the fourth section characteristics of e-Governance application ontologies are described. As an illustration two case study assets are proposed exploring the concrete services provided of the Bulgarian National Employment Agency (NEA) in the form of task ontologies. At the end conclusions and intention for future work are represented.

Ontology schema of e-Governance

According to holistic approach and depending on the model objectives, e-Governance can be regarded as a hierarchical system described by single ontology or by several mutually connected ontologies. We argue that the second option is more suitable because of easier creation, flexibility and reusability of small independent ontologies which could be used for different applications. Commonly, the ontology schema of e-Governance has following hierarchical levels (Figure 1):

- upper level (meta-ontology) of the electronic society (e-Society) used for expressing the general e-Governance concepts;
- second level (e-Governance domain ontology) – for declaring domain-dependent concepts and its relationships about e-Governance components which are independent from the specific national environment;
- third level – of application ontologies characterized by the instantiations of the concepts described at the second level and related to e-Governance of concrete countries and local authorities;
- and the bottom level covering task ontologies about structure, organization, methods and algorithms of different e-Governance round of services.

The development of e-Society meta-ontology is not subject of the current research but applying system approach simple taxonomy of its upper level is built (Figure 2). As a

system, e-Society is described by general concepts as environment, boundary, structure, state, service type and passing process. According to the conclusions in the above e-Governance ontologies overview, the structure of the e-Society includes at equivalent level subclasses e-Business, e-Citizen, e-NPNGO and e-Governance. Obviously, the e-Society environment is the real society as whole while the boundary is public computer network (in the case – Internet). Distinguishing from the above studied works, we consider that services between NPNGO, business and citizens are more e-Society services than e-Governance services. Therefore, the types of e-Society services are NPNGO-to-NPNGO, NPNGO-to-other (other-to-NPNGO), B2B, Business-to-other (other-to-Business) and Consumer-to-Consumer (or Citizen-to Citizen, C2C).

Further the domain ontology of e-Governance could be seen as instance of e-Society ontology. This domain ontology includes classification of e-Governance types and e-Governance components. In turn, the domain ontology assists in the lower level instantiations with a common representation language and can be reused in different situations belonging to the same domain. The existence of a common domain-dependent ontological description helps to avoid incompatibilities at the instance level, supporting therefore the comparison and the merging of different scene-dependent and domain-dependent descriptions. Moreover, it represents means for stimulating interoperability between different domain ontologies. However the instances could exist in concrete physical (real-world) environment only.

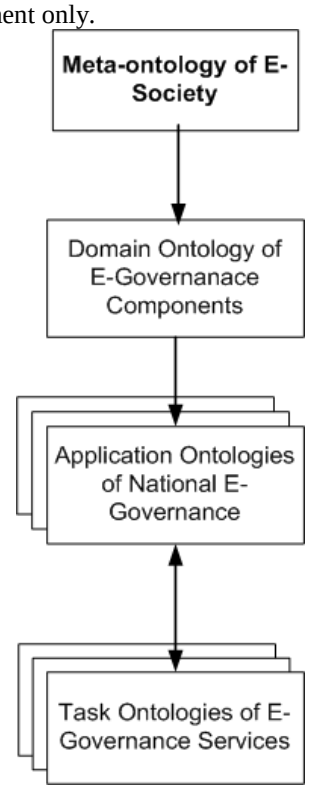

Figure 1. Ontology-based e-Governance model

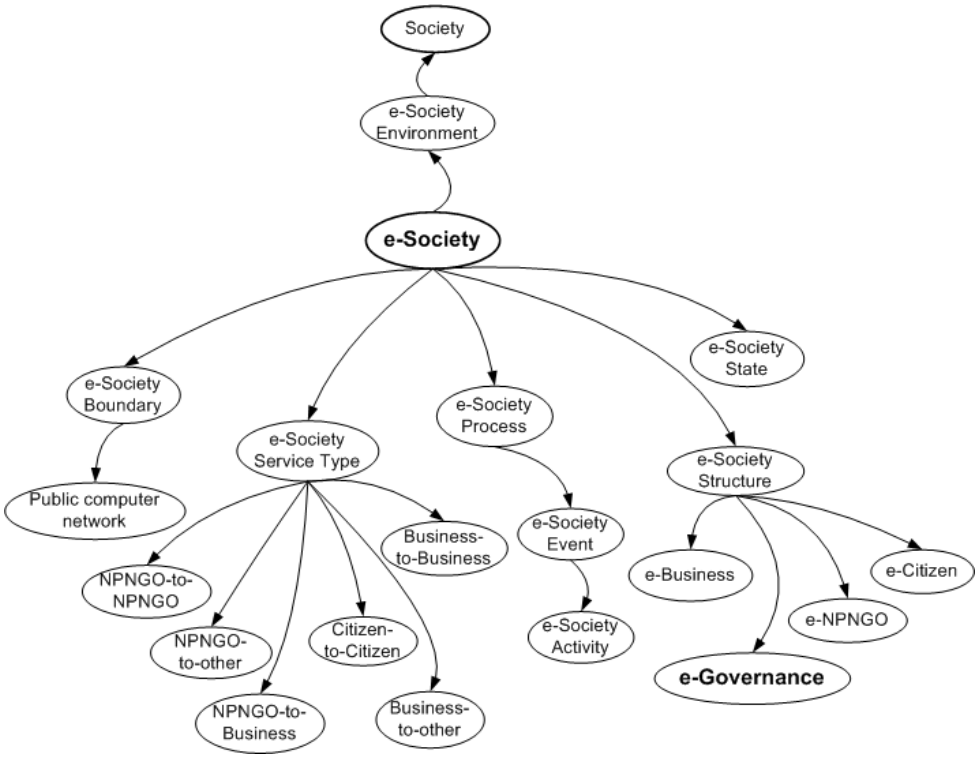

Figure 2. Upper level of e-Society taxonomy

Building domain ontology of e-governance

There are no commonly agreed methodologies about the development of shared and consensual ontologies [14] but all of them comprise the following consecutive stages:

- definition of resources and tools for ontology building, verification and publication;
- domain conceptualization and controlled vocabulary building;
- establishment of hierarchical relations between concepts and taxonomy building;
- definition of other ontology elements – non-hierarchical relations, facets (value restrictions on relations), instances etc., and subsequent ontology formalization;
- ontology verification;
- ontology publication (dissemination) with a view to its reusability.

Resources and tools for ontology implementation

The resources and tools for ontology implementation are mainly these of the Semantic web technology – standards, ontology languages, editors, repositories, verifiers etc. In this case e-Governance domain ontology is realized by OWL (Web Ontology Language) under Protégé 4.1 editor. The main reason of OWL choice is its possibility for mapping heterogeneous data sources to a common global schema in order to establish the

semantic relationship [1]. Moreover, OWL is proposed to be the ontology language for the Semantic Web [18].

Domain conceptualization and controlled vocabulary building

Conceptualization or extraction of common concepts (called also classes) in the investigated knowledge domain of e-Governance from various reference documents (papers, research reports, books, standards) is made. Arrangement of the concepts in controlled vocabulary follows.

According to ANSI/NISO Z39.19-2005 standard [15], controlled vocabulary is an alphabetically ordered list of concepts (terms) that have been explicitly enumerated and provided with unambiguous, non-redundant definitions. Following the guidelines an aggregate controlled vocabulary of e-Governance is built. Its concepts, for example – e-Society, e-Governance, e-Government, e-Democracy, e-Service, e-Citizen, e-Business etc., are introduced and supported in controlled vocabulary database [5, 11].

Establishment of hierarchical relations between concepts and taxonomy design

By [15] a taxonomy is a collection of controlled vocabulary concepts organized into a hierarchical structure. There are two main types of taxonomy:

- *subsumption* (classification) with hierarchical relations between concepts of type *is-a/has-a*;
- *mereology* (*partonomy*) including hierarchical relations of type *part-whole*, for example. is-part-of /has-part, is-member-of/has-member, etc.

The taxonomy could be represented in thesaurus database, by case tools, graphical software or ontological editors. Because of OWL and Protégé choice (see 3.1) the e-Governance taxonomy is described in Protégé environment and visualised by its OntoGraf module (Figure 3).

The top class *E-Governance* of the taxonomy according to the definition [19] has three main subclasses:

E-Governance ∋ *E-Government* ∧ *E-Democracy* ∧ *E-Governance-Document*

In turn:

E-Government ∋ *E-Government-Structure* ∧ *E-Government-Service*

The structure of e-Government corresponds to the real one:

E-Government-Structure ∋ *e-Ministry* ∧ *e-Department* ∧ *e-Local-Government*

etc. while its services are subdivided mainly in two types – by actors (participants) and by kind of activity.

E-Government-Service-by-Actors ∋ *Government-to-Government* ∧ *Public-E-Government* ∧ *Government-to-Employee*

E-Government-Service-by-Activity ∋ *E-Administration* ∧ *E-Security* ∧ *E-Education* ∧ *E-Social Care* ∧ *E-Library* ∧ *E-Court*

etc. On the other hand, class E-Democracy have similar taxonomy, including services and structure:

E-Democracy-Service ∋ *E-Engagement* ∧ *E-Participation* ∧ *E-Consultation*

E-Democracy-Structure ∋ *E-Political-Organization* ∧ *E-Local-Community* ∧ *E-Judiciary* ∧ *E-Parliament*

etc. Class E-Governance-Document comprises e-documents used in e-Governance subdivisions and services distinguished in two types:

E-Governance-Document ∋ *E-Governance-Document-by-Service* ∧ *E-Governance-Document-by-Function*

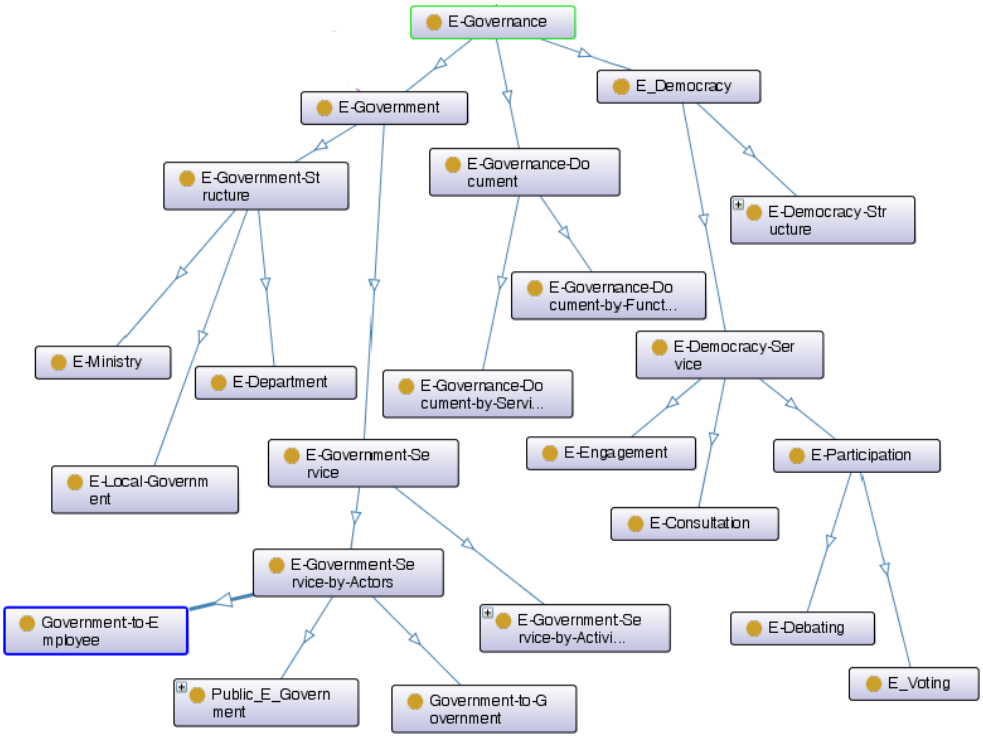

Figure 3. An excerpt of e-Governance taxonomy

There are other subclasses of e-Government and e-Democracy services and structures but here are indicated frequently encountered ones found in different sources. On the figure above four hierarchical levels are represented but actually in the taxonomy database there are over 80 classes in more levels.

Definition of non-hierarchical relations and ontology formalization

To build an ontology its taxonomy has to be extended with non-hierarchical (equivalence and associative) relations (still called ontology slots, properties or attributes). Relations of equivalence represent synonyms and near synonyms of classes and are very important for terminology synchronization. For example:

$$E\text{-}Government \xrightarrow{has-synonym} Electronic\text{-}Government$$

$$E\text{-}Government \xrightarrow{has-synonym} Online\text{-}Government$$

etc. Associative relations are concerned to metrics, quality, standards, etc. and require addition of facets and instances. For example:

$$E\text{-}Government\text{-}Service \xrightarrow{has-protocol} E\text{-}Government\text{-}Network\text{-}Protocol$$

$$E\text{-}Government\text{-}Network\text{-}Protocol \xrightarrow{has-instance} Interoperability\ Interface\ Protocol\ (IIP)$$

According to the above considerations domain ontology of e-Governance is accomplished and formalized as is shown in Protégé screenshot (Figure 4). Besides taxonomy of classes non-hierarchical relations, facets and instances are included.

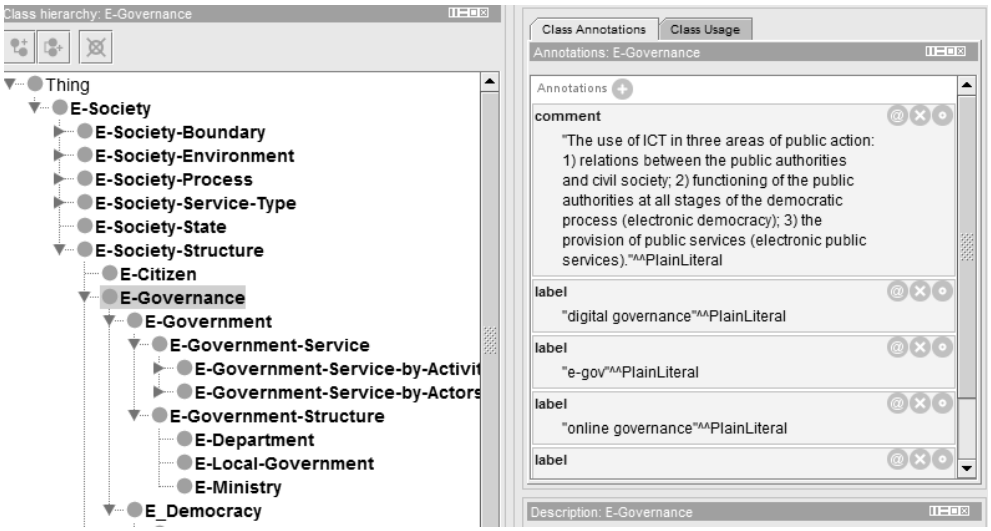

Figure 4. A part of domain ontology of e-Governance

A part of non-hierarchical relation list is shown on Figure 5. It contains so called object properties which are relations between instances of two classes [18].

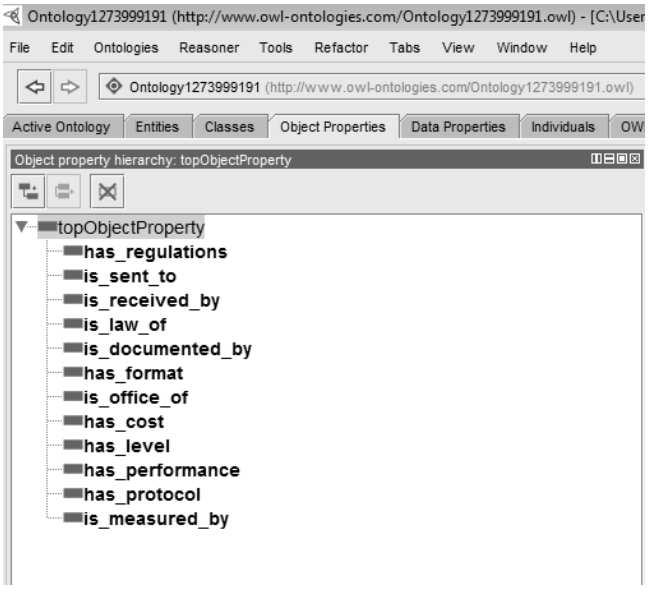

Figure 5. An excerpt of relation list

E-Governance application and task ontologies

The proposed e-Governance domain ontology is starting point for development of application and task ontologies about e-Governance at national level.

Application ontologies of e-Governance

The application ontologies could be seen as instances of e-Governance domain ontology. Any particular state system has specific language, structure, activities etc. But by our opinion the more of respective e-Governance application ontologies should have the same upper level classes. Thus, the presence of commonly accepted domain ontology would facilitate creation of application ontologies. On the other hand, because of national specifics these application ontologies are not fully reusable. The difference can be in national e-Governance structure, service procedures and related documents. For example, the application ontologies of French or England e-Governance have e-Chamber subclass of E-Parliament class while in Bulgarian or Finland e-Governance application ontologies E-Parliament has no such subclass.

As example Bulgarian E-Governance application ontology is developed and an excerpt of its taxonomy on Figure 6 is given. Detailed description of e-Governance documents, services and structure is implemented.

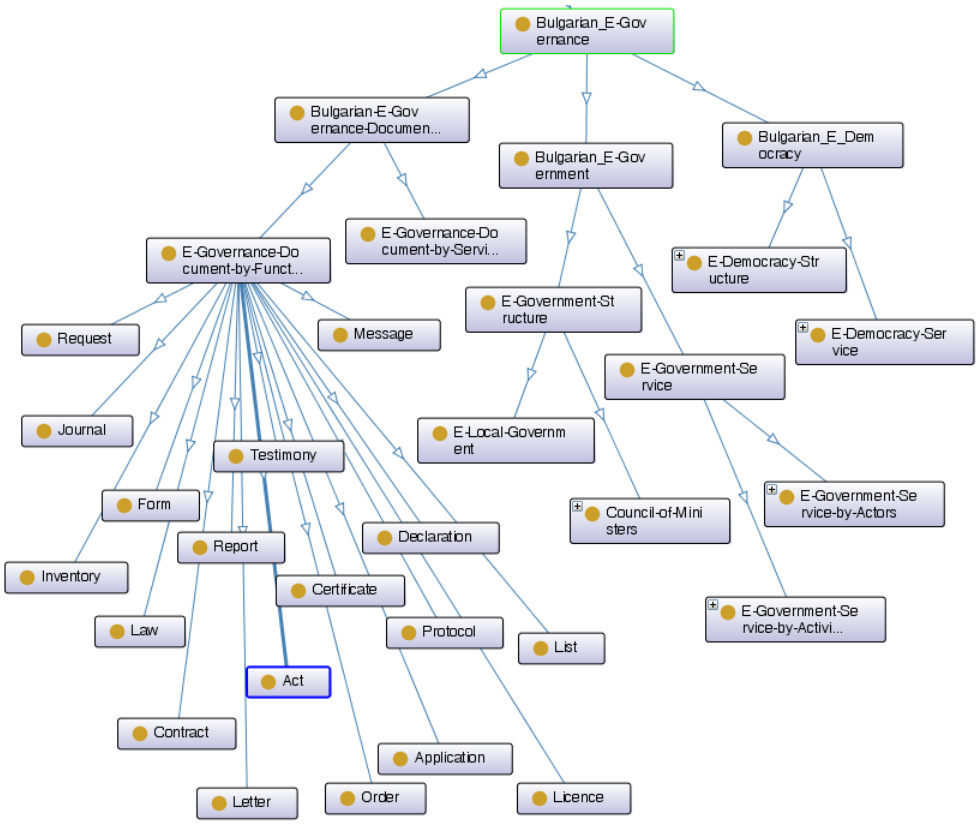

Figure 6. A part of Bulgarian E-Governance taxonomy

Further, on the base of developed application ontologies task ontologies (considered as case study assets) of particular e-Governance services could be created. They represent concrete service procedures and their classes have instances as databases, information systems, software applications, algorithms, standards, legal documents, physical prototypes etc. used in service implementation. Two examples are developed taken from Bulgarian e-Governmental portal [7] as a part or EUGO network of country websites across the European Union (EU) and European Economic Area (EEA) [28].

Task ontology about work place providing

Task ontologies oriented to the job seekers are needed to trace out the procedures at the Bulgarian National Employment Agency (NEA) [22] to the Bulgarian Ministry of Labour and Social Policy. The structure of NEA includes Local Employment Offices (LEOs) that implement the government policy on employment promotion at local level. In general, the NEA as mediator providing work places performs the following services (or activities) for citizens actively seeking job within the country or abroad:

- Information and Consultation on all NEA services;
- Hiring appropriate candidates searching jobs and for subsidized employment;
- Proposing professional guidance;
- Career (professional) orientation;
- Psychological support;
- Employment register support including job seeker's and job vacancies data;
- Qualification and motivation training;
- Involving in relevant programs and measures for employment.
- Information and preparation in cases of mass redundancies etc.

The top class of the Bulgarian E-Job-Providing task ontology is instance of class E-Job-Providing (subclass of class E-Job of the e-Governance domain ontology) (Figure 7).

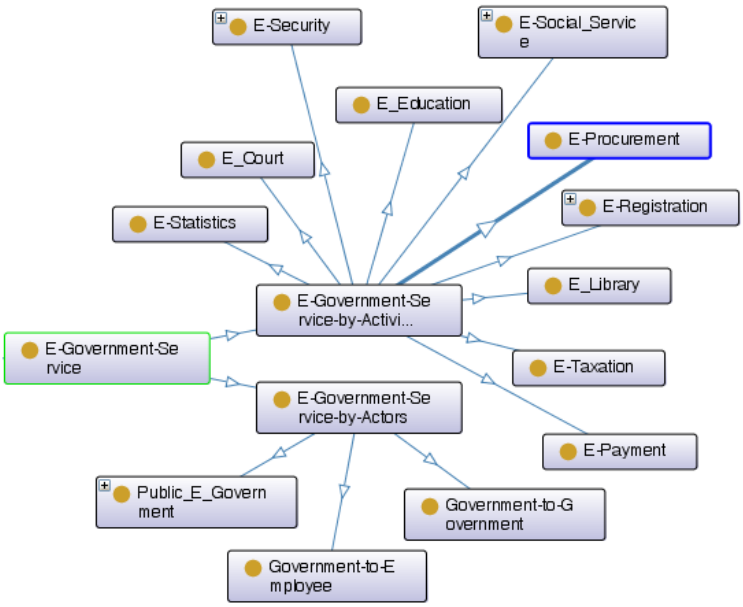

Figure 7. Taxonomy of class E-Government-Service

This task ontology as a kind of process ontology has following main subclasses: E-Job-Activity, E-Job-Goal, E-Job-Agent and E-Job-Tool. Class E-Job-Activity comprises the above procedures and their decomposition. The goal of e-Job providing is unemployment decreasing with two subgoals – employee qualification improvement and labour market statistics support. Class Job-Agent refers to participants in e-Job providing activities – Job Seeker, Employer and E-Job-Mediator. The necessary software, documents and regulations as subclasses of class E-Job-Tool are described, namely:

- Employment-Register (Employment database) with instance LEOs common e-Register;
- Regulatory – with subclasses Employment-Tariff, Employment-Ordinance and Employment-Law;
- E-Job-Document – with subclasses Guidance-Letter, Guidance-Letter-with-Profile, Job-Request-Form and Registration-Request-Form.

The specifics of Bulgarian e-Job providing is expressed by instances of these tools.

Detailed task ontology Bulgarian E-Job-Providing is developed and part of its taxonomy is presented by OntoGraf module of Protégé (Figure 8).

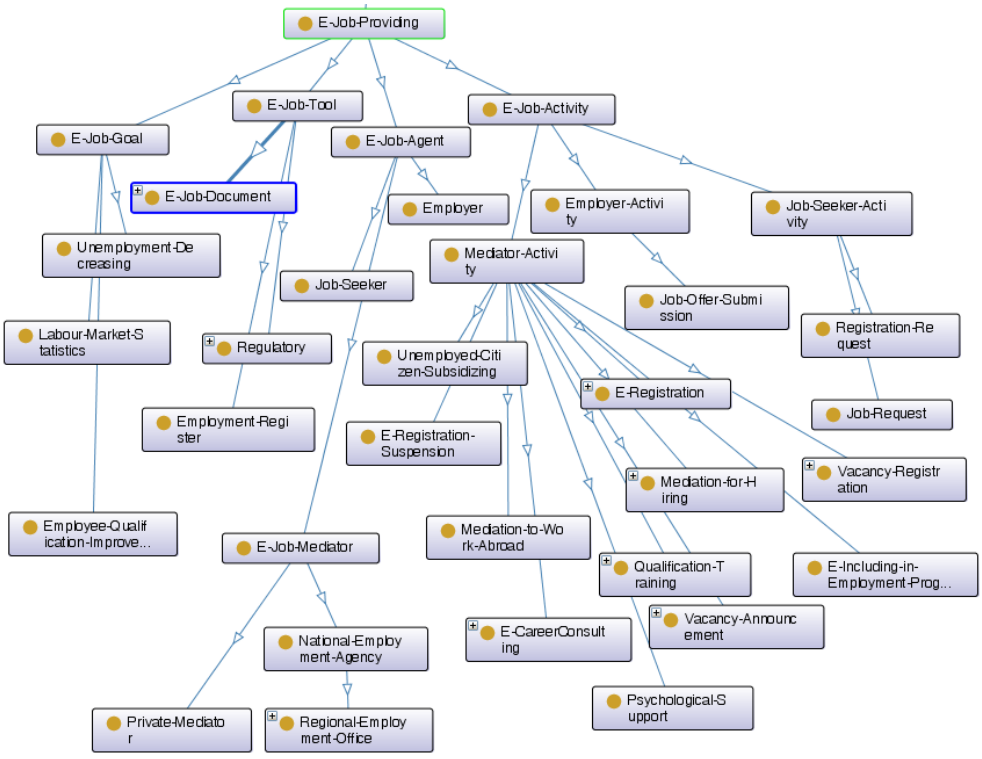

Figure 8. Excerpt of taxonomy of Bulgarian E-Job Providing service to the job seekers

Task Ontology of a Service "E-Registration of Unemployed Citizens"

Another example of Bulgarian e-Governance task ontology is the service “E-Registration of Unemployed Citizens” as a part of E-Job-Activity service. By [28]:

> "various kinds of registration like birth registration or citizenship registration, property registration, license registration etc. should be done. Registration is necessary because constitutional categories have to be linked with actual natural entities like human beings and land".

It is e-Governance service that aims in simplifying the whole procedure of finding the appropriate job for the citizens and reducing the unemployment rate as a result of this. The authority that provides this e-service is again NEA [22]. The registration is made in the LEOs common e-Register.

The taxonomy structure follows the logics of the E-Job-Providing task ontology. The top class E-Registration-of-Unemployed-Citizen is subclass of E-Job-Activity. Its first level subclasses are E-Registration-Event, E-Registration-Tool, E-Registration-Agent and E-Registration-Goal. Further decomposition of these subclasses of Figure 8 is shown. On the next levels more detailed classes about the procedures, requirements, documents, performers and resources for this e-service are represented.

The next Figure 9 shows the taxonomy graph. It represents the whole process of accepting application forms and registration of unemployed citizens in similar graphical manner.

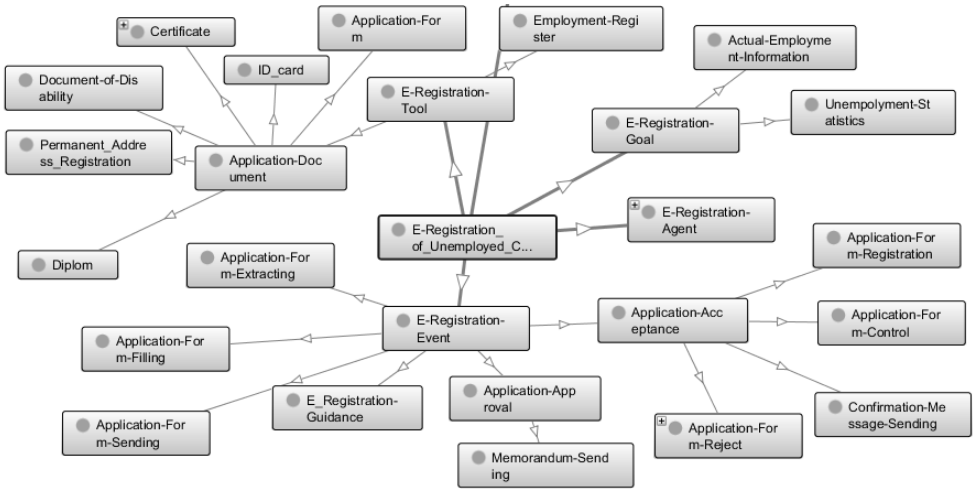

Figure 9. Taxonomy graph of Bulgarian unemployment registration task ontology

By analogy, particular task ontology of each e-Governance service (e-Security, e-Health, e-Education, e-Payment, e-Procurement etc.) could be developed.

Conclusions and future work

These ontologies, built as a result of our research and design, are necessary tools for incorporation into distributed web-based e-Governance information and decision making systems used at different levels of the hierarchy of the public organizations. But such innovative approach of designing and exploitation of e-Governance systems and processes is not widely distributed due to the lack of trained specialists, and lack of

understanding from the public organizations of the importance of standardization and structuring by ontologies of knowledge necessary for any practical assignment.

The entity e-Governance in global aspect has to be adequately translated and defined into various languages with conformity of the terminological level. Further detailed development of its domain ontology follows. Then application and task ontologies at national level for the various services in e-Governance is indispensable.

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[1] Unified Modeling Language (UML) is an ISO specification language for modeling objects since 1994 (Booch 2007). Primarily created for software system development, now UML diagrams are used for different systems and processes modeling – for example, business processes, organizational structures etc.

[2] assets are controlled terminologies and mapping tables, also in their representations as taxonomies, ontologies and thesauri (SEMIC, 2010).