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TOWARDS FACILITATED REUSE OF ONTOLOGY RESULTS FROM EUROPEAN RESEARCH PROJECTS – A CASE STUDY

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Abstract

A significant amount of results have been produced recently in the area of ontology research. Increasingly semantic concepts are applied not only to enable system to system interaction and data exchange through unambiguous modelling of a certain domain, but also to enable univocal communication between human beings working on a certain domain. Reuse of ontology research results is however hindered by different underlying meta-models, incompatible formalization and the limited availability of content. In this paper we therefore analyse issues of reusing ontologies in the context of an ongoing research project that aims to develop a methodology for modelling the process landscape of public administrations in order to measure qualitative and quantitative impacts of Information and Communication Technology using semantic models and reasoning functionality. Seven ontology research projects are identified to be relevant candidates for reuse in this project and are categorised by relevant characteristics of reuse. Based on this analysis, a framework that defines required information to enable accurate characterisations of ontology research results in an ontology library system is presented. Thereby existing approaches are extended in order to enable discovery and facilitate reuse of ontology results from European research projects based on structural and content-related information.

Keywords: ontologies, ontology support, evaluation, frameworks & models

1 INTRODUCTION

The concepts of ontologies are an accepted field of research both in the computer science and information systems domain. Increasingly semantic concepts are applied not only to enable system to system interaction and data exchange through unambiguous modelling of entities and their interrelations in a certain domain, but also to enable univocal communication between human beings working on a certain domain such as process optimisation in public administrations.

In particular the second approach which defines taxonomies and/or models of a certain domain, which are human comprehensible but also formally described using a certain ontology language, provides large potential and is therefore subject to research in many contexts. In particular enabling automation of complex interaction through software applications by the use of automatically or semi-automatically analyzable models of processes or data exchange patterns is a use case for semantic models (ATHENA, 2007; Missikoff et al., 2006).

The European funded project PICTURE aims to use these concepts for developing a methodology and a tool for modelling the process landscape – referring to the overall set of processes within an administration – and measuring qualitative and quantitative impacts of Information and Communication Technology (ICT) using semantic models and reasoning functionality (Baacke et al., 2006). In the past a number of research projects have been addressing issues of interoperability and process efficiency in the government domain using ontologies. In order to ensure quality of the outcomes of the PICTURE project and to benefit from existing knowledge the authors therefore investigated into results from existing projects on ontologies which are relevant to the addressed topics.

As relevant to the concept of semantically annotated process models which enable semi-automated analysis, a set of seven projects were identified that address the ontology application areas of supporting process modelling, interoperability between public administrations as well as service provisioning for customers of public administrations. While these projects were all funded by the same institution, namely the European Commission under the Sixth Framework Programme, they lack compatibility despite their overlap in many areas. This contrasts the benefits of reusing ontologies like time and cost savings during the construction process or quality improvements by e.g. integrating or merging appropriate ontologies which are well accepted (Bontas et al., 2005; Pinto and Martins, 2000; Doran, 2006; Uschold et al., 1998). This paper therefore comprises a case study that analyses afore mentioned projects with regards to relevant characteristics of their reuse. The paper aims to support the hypothesis that a central ontology library system is fostering reuse potentials and standardisation in the field of European ontology research results. Having analysed a number of concepts it proposes a framework that provides required information to realize accurate characterisations of ontologies in order to enable discovery and facilitate reuse of ontology results from European research projects.

In the following section the paper presents and compares existing ontology projects relevant to our project as well as their addressed domains. Having derived relevant criteria from the before mentioned analysis in section 3, a systematic analysis of the projects' results is carried out in section 4 with regards to the categories application area, formalisation (meta-model and description language), instantiation concept and – core to reuse – content availability. Based on this categorisation as well as an analysis of further state of the art concepts for categorizing and storing ontology projects, in section 5 an approach to centrally register and describe such ontologies in a shared repository is described which facilitates reuse of existing knowledge of semantic taxonomies and models for certain domains and application scenarios.

2 RELEVANT STATE-OF-THE-ART ONTOLOGY PROJECTS IN THE GOVERNMENT DOMAIN

In the context of our research work in the e-Government area we encountered the problem that we would need two types of ontologies supporting the main goals of our project. We aim at enabling end-users to describe as-is processes in public administrations in order to analyse these processes using semantic technologies like ontology reasoning mechanisms to identify certain weakness patterns that can be optimised using ICT.

- An ontology is required to categorise the processes executed in the back-office of a public administration
- An ontology is required that enables representation of legal facts and constraints that have to be considered when modelling or executing processes in a public administration

The first ontology will be used to facilitate structuring the large amount of processes that need to be modelled in a public administration. The second ontology will serve as the basis for verification of process models to ensure that they actually follow the applicable laws and regulations.

We identified a set of seven projects from the large pool of research projects in the e-Government area, an overview is provided in (European Commission, 2007). Selection was carried out by analysing the list of projects provided in (European Commission, 2007) and a list of projects identified by querying the database of projects funded by the European Commission under the 6th Framework Programme (FP6) (European Commission, 2008) with the search terms “eGovernment” and “e-Government”. Relevant projects were identified based on an analysis of the project description with regards to their relevance to the application areas mentioned above, in particular ontologies for back-office-processes categorisation and representation of legal facts and constraints.

In the following we briefly summarise the goals of each project considered before actually carrying out the categorisation. We treat the two problem areas separately as most likely different ontologies will be necessary to address the different issues.

The major criterion for considering a project in our evaluation was the relevance of their results to our problems. This means, that the project is required to address the e-Government domain, that it applies semantic technologies, that it uses or creates ontologies and that it is covering at least one of the two problem areas described above.

Application of these selection criteria to the list of projects available at (European Commission, 2007) has led to the following seven projects which undergo a more detailed analysis in the subsequent section:

Access-eGov (Access eGov Consortium, 2007):

This project aims to develop and validate a platform for composition of government services into complex process definitions (covering life events/business episodes) enabling semantic interoperability of particular e-Government services. It will particularly support the citizen searching for a certain service.

FIT (FIT Consortium, 2007):

This project aims at developing, testing and validating a self-adaptive e-Government framework based on semantic technologies that will ensure that the quality of public services is proactively and continually fitted to the changing preferences and increasing expectations of e-citizens. Therefore, information about action a citizen performs on an e-Government portal will be logged and semantic data mining techniques are applied to that data to detect anomalies in the design of the portal whose repair can improve usability. Discovered knowledge is incorporated in existing administrative processes through business rules.

LD-CAST (LD-CAST Consortium, 2007):

The project aims at enabling cross border cooperation between European chambers of commerce (CCs) in order to support the development of private company initiatives. The project will build a European network of LD-CAST portals that will enable end users (mainly private companies) to access in a seamless mode the services provided by public organisations registered in each LD-CAST portal.

OntoGov (OntoGov Consortium, 2006):

The goal of the OntoGov project is to improve back-office processes in public administrations by taking into account the whole lifecycle. The OntoGov system will allow for change propagation and traceability, contributing in this way to the bridging of decision-making with technical realisation (e.g. updating the services used in the back-office processes due to changes in national and European legislation).

OneStopGov (OneStopGov Consortium, 2007):

This project aims at specifying, developing and evaluating a life-event oriented, all-inclusive, integrated, interoperable platform for online one-stop government. The OneStopGov platform will be based on the life-event ontology which enables proper representation of the life-event concept. An active life-event portal will be implemented to care for citizens' needs and circumstances. In addition to that a complete set of life-event reference models will be specified to allow implementing virtually any life-event. These reference models are then intended to be implemented using generic workflow web technologies.

SemanticGov (SemanticGov Consortium, 2007):

The project aims at building the infrastructure (software, models, services, etc.) necessary for enabling the offering of semantic web services by public administrations. It aims at capitalizing on the Service Oriented Architectures paradigm, implemented through state-of-the-art Semantic Web Services technology and supported by rigorous and reusable public administration domain analysis and modelling. It intends thereby to be in line with all major European programmes and initiatives in the field e.g. the European Interoperability Framework and the recent work conducted by the EU "Interoperable Delivery of European e-Government Services to public Administrations, Businesses and Citizens" (IDABC) Programme, the forthcoming i2010 group of Member States representatives and the Competitiveness & Innovation (CIP) Programme.

Terregov (Terregov Consortium, 2007):

This project aims at making it possible for local, intermediate (municipality groupings, districts, etc.) and regional administrations to deliver online a large variety of services in a straightforward and transparent manner regardless of the administration(s) actually involved in providing those services. This supports local administrations to act as a front office to the citizen whilst at the same time using services from different administration to fulfil the citizen's request.

3 CRITERIA RELEVANT TO ASSESSING REUSE POTENTIAL OF ONTOLOGY PROJECTS

To structure evaluation of relevant ontology research results and to facilitate comparison and determination of appropriate results for reuse we have identified a set of criteria which are relevant for the area of ontology research results. These criteria describe relevant characteristics of ontology research results which determine its application domain and mode of application and are therefore required information for assessing its reuse potential for new aspects not addressed by their original purposes.

We consider the following four criteria being relevant for the task to be accomplished:

- application area
- formalisation
- instantiation concept
- content availability

In the following these criteria are described in more detail before being applied to the identified seven projects in the subsequent section.

3.1 Application Area

Ontologies are recognized within computer science and information systems research for various purposes. Guarino (1998) distinguishes between research fields and application areas of ontologies. Within that categorization the presented paper refers to the research field of information retrieval and extraction as well as knowledge management and addresses the following application areas within the domain of e-Government:

- support process modelling and execution in public administration
- support interoperability between public administrations and execution of cross-organisational processes
- support service provisioning / offering for customers (citizens or businesses)

The first application area deals with providing ontologies that support and improve in any way the modelling and execution of administration-internal processes. Supporting internal employees in identifying the appropriate steps to fulfil a request or to flexibly adapt processes to changing surrounding conditions could be examples for this application area.

The second application area supporting interoperability between public administrations focuses on all measures that improve the cooperation between public administrations. Particular focus for our investigation is put on approaches that support modelling and execution of cross-organisational processes and deal with interfaces between administrations.

The third application area focuses on the customer interface of public administrations. Here ontologies are typically used to structure the service offerings for citizens or businesses or to improve the usability and adaptability.

3.2 Formalisation

The second criteria for the evaluation deals with the meta-model of the ontology created. With meta-model we refer to the classes and relationships that are part of the ontology. These can differ between different ontologies. In addition, the concepts have to be described in detail so that comparisons can be made. The availability of the names of classes and relationships is not sufficient as these can be ambiguous. Therefore, a detailed formal and verbal description of the ontology meta-model is needed to compare and effectively decide if a particular class or relationship is of relevance for the intended usage.

Different standards and tools are available to represent ontologies and to support maintenance and instance creation. However there is a lack of compatibility between open standards and description languages of proprietary applications. These incompatibilities hinder reuse; therefore the selected description language and its standard-compliance are subject to evaluation.

Relevant standards and proprietary description languages are for example the following:

- OWL (World Wide Web Consortium, 2007) – the web ontology language: It provides a standardised format to represent ontologies and in particular addresses requirements imposed by the world wide web.

- KAON (KAON, 2007): It provides an open-source ontology management infrastructure targeted for business applications. KAON includes a comprehensive tool suite allowing easy ontology creation and management and provides a framework for building ontology-based applications. It is available in two releases - KAON and KAON2. While KAON2 is based on OWL description language, the more widely used KAON uses RDF with proprietary extensions.
- WSML – Web Services Modelling Language – and related tools (WSMO, 2007): WSML is a language for modelling semantic web services which the WSMO working group aims for standardisation.

In addition to these examples several projects are creating own tools to support modelling and handling of ontologies as the existing ones – according to the researchers – do not fulfil their requirements (Terregov Consortium, 2007).

To evaluate the reuse possibilities, another relevant aspect is the used tool for developing an ontology and the respective formal description language. This is particularly relevant if the applied language is not standard-based and access to the original tool is not generally available (e.g. due to license issues).

3.3 Instantiation Concept

We can distinguish different possibilities to create instances of ontologies which also influence the reuse possibilities:

- per public administration (PA)
- general plus specialisation
- one for all

In the first case a new instance of an ontology is created per public administration. This is often the case when the ontology models concepts that are specific per country or per administration. However, this option limits the re-usability as lots of different instances exist that would have to be integrated.

In the second case a general (template-) ontology is created and can then be specialised to represent individual facts in different public administrations. This approach fosters reuse but still allows for a significant amount of individual content.

In the third case one general purpose ontology exists that can be used in all administrations. For extensions to this ontology a central decision point or a consensus approach is needed.

3.4 Content Availability

This criterion covers the availability of concrete content for a particular ontology. Content in this case relates to availability of instances of the ontology such as example instances or reference instantiations for reuse. This content is often kept at the individual contributors and not made available to the general public. In particular for research projects we face the problem that content may be available during the project runtime. But after the project is finished the website is closed and the content is no longer available.

4 COMPARISON OF STATE-OF-THE-ART PROJECTS

The basic assumption for the comparison is that only publicly available information is used. That means we only use information from the project website or from papers published about the project. We did not take into account information that could be retrieved e.g. by directly contacting the project coordinator.

4.1 Comparison for process categorisation

We first discuss the detailed comparison results for the group of ontologies that address process categorisation (cf. section 2). Table 1 shows the results of the comparison of ontology results of that group.

A first result of the comparison is that different wording is used to denote this problem area. We have found process ontology, service ontology, life-events or business episodes to describe some kind of process categorisation. Due to their validity and applicability also in parts, closely related ontology concepts are also considered being relevant for reuse. For instance, some projects do not consider the complete landscape of processes in an administration in their concrete use cases. However, they still provide relevant content. Therefore, we enclose all seven projects in this comparison.

A classification regarding the application area, the formalisation used and the instantiation concept of the seven projects is presented in the following based on information provided by the projects. With regards to content, for no project complete information is publicly available. Regarding formalisation and the respective description language used in the projects, a broad range from standards-based representations up to own developments exists.

For some projects a description of the meta-model is available, e.g. through public project deliverables or through papers. For the sake of readability we only denote here if we have found public information about the meta-model on the project website respectively in publications or not. An entry in brackets indicates that only some information is available, not the complete meta-model.

	Application area	Formalisation (language / tool)	Instantiation concept	Content availability
Access-egov	service provisioning	WSML	general plus specialisations	not publicly available
FIT	service provisioning	OWL (KAON)	per PA	not publicly available
LD-Cast	process interoperability	not publicly available	one for all	not publicly available
OntoGov	process execution	OWL (KAON)	per PA	not publicly available
OneStopGov	service provisioning	not publicly available	one for all	not publicly available
SemanticGov	service provisioning	WSML	per PA	sample instances available in deliverables
Terregov	process interoperability	OWL / own development	per PA	available after registration

Table 1 Comparison results for process categorisation ontologies

4.2 Comparison for legal ontologies

For our second group (cf. section 2), the creation of a legal ontology that represents laws and regulations applicable to processes in public administration, we have a much smaller set of projects to be considered. This is due to the fact that the semantic representation of legal facts is quite complex and considered in more specialised research projects which are also covering different research areas. To stay focused in our evaluation we only consider the two projects in the area of e-Government that also cover legal facts. Table 2 shows the results of the evaluation.

The two projects use the legal ontologies to facilitate process execution and adaptation respectively service provisioning. Meta-model descriptions are available in deliverables and publications. Regarding the formalisation information could only be retrieved for one project. Also no content of instances is publicly available.

	Application area	Formalisation (language / tool)	Instantiation concept	Content availability
OntoGov	process execution	KAON	per PA	not publicly available
OneStopGov	service provisioning	not publicly available	one for all	not publicly available

Table 2 Comparison results for process taxonomy

5 FOSTERING REUSE THROUGH A REPOSITORY OF ONTOLOGY PROJECTS

While analyzing the ontology projects in section 4 it stood out, that the reuse of those ontologies has been restrained due to several reasons. The availability of information about the projects and the engineered ontology could be seen as one of the most critical aspects. Project websites are closed down sometime after the project end respectively public deliverables are removed from the websites hence information is no longer available to persons outside the project consortium. The usage of different description languages is another limiting factor for an effective and efficient reuse of the project results and especially their ontologies.

For example, ontologies from areas like service catalogues or life-events are from a conceptual perspective quite similar concerning their classes and relationships. A reuse of those ontologies and integration is therefore definitely conceivable. However, the critical point that hinders integration efforts is the availability of the content needed for an evaluation of differences and respective efforts for combining them. A library system storing the different EU driven ontology projects in a consistent and reusable way would be a valuable instrument enabling a shared knowledge conceptualisation (Bontas et al., 2005). Those systems are to some extent considered as a key for successful ontology reuse (Ding and Fensel, 2001). By means of these systems the availability of results could be ensured, in our case of EU projects even if a project has come to its end. As a consequence redundancies concerning the content could be avoided if ontologies are not each time constructed from the scratch. In the following we will therefore analyse existing library systems and compare them to a set of requirements that we derived from the previously described categorisation. On this basis we will then propose a new concept of ontology library systems that extends existing approaches with information relevant to retrieving relevant ontologies for a certain problem area or domain.

5.1 Existing ontology library systems

This section depicts existing approaches for storing and maintaining ontologies based on prior work in that domain (Ding and Fensel, 2001; Doran, 2006). The analysis of the library systems carried out comprises the following systems: WebOnto, Ontolingua, DAML, SHOE, Ontology Server, IEEE Standard Upper Ontology, OntoServer, ONIONS, Swoogle, OntoSearch and OntoSelect. Their websites as well as the availability/online status (accessed 29.11.2007) and the respective research group or organisation that has propagated the library are shown in Table 3.

Many of these approaches have been research projects that are completed; hence some of the systems are no longer available in the internet. In addition most of the systems that are still available lack detailed metadata including information like the domain which the ontology has been engineered for or features like a key word or topic search. As pointed out before, ontologies are often represented in different description languages, which is a further influencing factor that hampers an effective and efficient reuse.

Moreover due to rather unstructured storage and representation techniques of the ontologies a differentiation between different variants of an ontology (generic variant or concrete instance) is also not covered by the inspected library systems. This is closely related with the issue whether a certain

ontology is part of an upper-level ontology or not (see below). Finally none of the ontology projects of section 2 have been stored in any of the analysed systems. Therefore, considering all the issues presented a strong demand for an ontology library system with certain characteristics for storing the results of EU driven projects can be derived.

Ontology library system	Organisation / Host	URL	Availability status
WebOnto	Knowledge Media Institute - The Open University	http://kmi.open.ac.uk/ projects/webonto/	Available
Ontolingua	Knowledge Systems, AI Laboratory, Stanford University	http://www.ksl.stanford.edu/ software/ontolingua/	Not available (due to proxy problems)
DAML	DARPA Agent Markup Language Program	http://www.daml.org/ ontologies/	Available
SHOE	Department of Computer Science, University of Maryland	http://www.cs.umd.edu/ projects/plus/SHOE/	Not available
Ontology Server	Semantics Technology & Applications Research Laboratory, University of Brussels	http://www.starlab.vub.ac.be /research/dogma/ OntologyServer.htm	No web application – no content in terms of ontologies provided
IEEE Standard Upper Ontology	IEEE Standard Upper Ontology Working Group	http://suo.ieee.org/	Available
OntoServer	Institute of Applied Informatics and Formal Description Methods, University of Karlsruhe	http://ontoserver.aifb.uni-karlsruhe.de/	Not available
ONIONS	n/a	http://saussure.irmkant.rm.cnr.it/onto	Not available
Swoogle	UMBC ebiquity research group, University of Maryland	http://swoogle.umbc.edu/	Available
OntoSearch	University of Aberdeen Computer Science Department	http://www.ontosearch.org/	Available
OntoSelect	German Research Center for Artificial Intelligence	http://olp.dfki.de/ontoselect/	Not available

Table 3 Ontology library systems

5.2 Developing a requirement framework

Having clarified the problems one will encounter while using a library system the aim of this section is the proposal of a framework containing requirements for extending such systems. We therefore rely on several concepts found in literature that prove to be beneficial for reusing ontologies including structural search criteria (Hepp, 2007) and general requirements (Ding and Fensel, 2001) and enhance the framework with content criteria for the comparison or search of ontologies identified from the analysis in section 3.

Due to the high number of engineered ontologies categorisations of ontologies have been developed such as the six characteristic variables of an ontology project in (Hepp, 2007). This categorisation differentiates between the following aspects: expressiveness, size of the relevant community, conceptual dynamics in the domain, number of conceptual elements in the domain, degree of subjectivity in a conceptualisation, average size of the specification per element. Expressiveness can be considered as the degree of formalisation of an ontology, the size of the relevant community informs about the numbers of human actors of a community that may be interested in applying a certain ontology. Conceptual dynamics is an indicator that provides information about „the amount of new conceptual elements and changes in meaning to existing ones per period of time“ (Hepp, 2007). The number of conceptual elements in the domain as well as the average size of the specification per element relate to the size of the ontology itself and of the specification of an average element, respectively. The degree of subjectivity cannot be quantified as univocal as the before mentioned criteria but will nevertheless be considered in the course of this paper as a structural search criteria.

The general requirements of an ontology library system described in (Uschold et al., 1998) address rather technical questions. They comprise three main aspects: management, adaptation and standardisation. The management aspect addresses the aspects storage, unique identification of an ontology and versioning. Issues such as search, edit, evaluation and verification (reasoning) of an ontology are covered by the aspect of adaptation. Finally questions about the standardisation are the third category of requirements presented in (Uschold et al., 1998) including first the number of supported description languages and second the question whether an ontology is grounded in an upper-level ontology like Upper Cyc Ontology, MikroKosmos, IEEE upper-layer ontology etc.

Based on the presented existing concepts as well as the issues identified in this paper, figure 1 depicts the three main aspects of *structural and content search criteria* as well as *general requirements* that are considered essential for creating an ontology library system. The criteria for assessing an ontology presented in section 3 (application area, description language, instance creation and content availability) are content related and should be used as search criteria. They extend the afore mentioned structural criteria in addition with general requirements that are equally important and should be considered as pointed out in (Uschold et al., 1998). These search criteria will then need to be enhanced with classic search functionalities within a library system such as querying for the name of the ontology or the topic or the relevant domain.

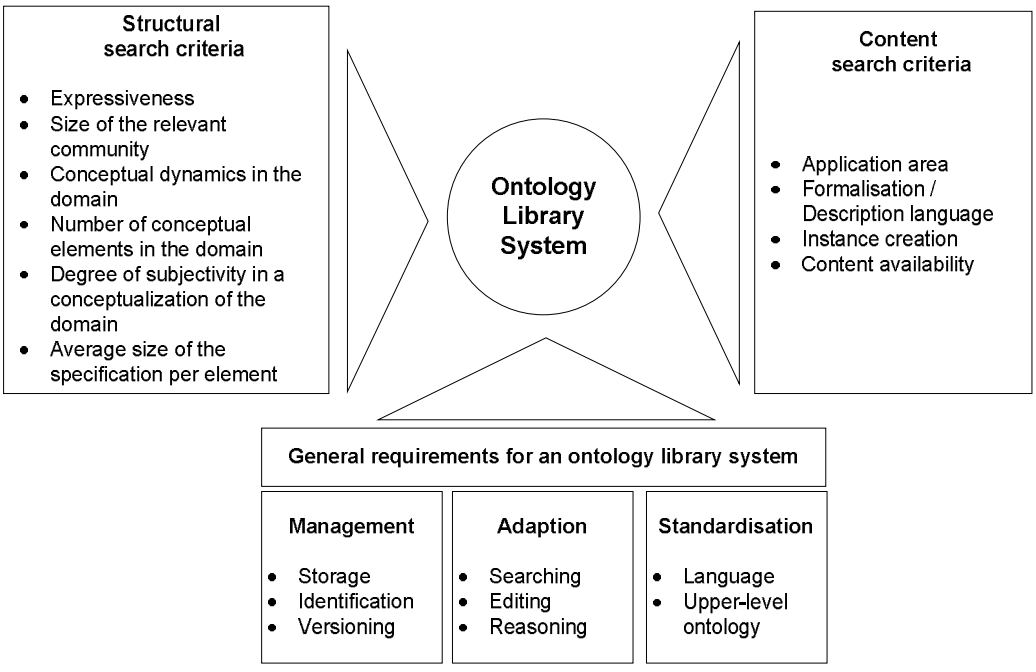

Figure 1 Proposed search criteria for a central ontology library system for European projects

The issue of modularisation of ontologies is a further aspect that needs to be taken into consideration. Especially in the fields of reuse of ontologies it is important to create mechanisms to enable the ontology engineer to use only parts of a certain ontology for application in the relevant context (Doran, 2006). This component orientation affects especially the construction of ontologies but would have also consequences for the library systems that are storing those component-based ontologies.

6 CONCLUSIONS

As our vision each ontology project should be stored in a library system in order to enable and foster reuse. We therefore suggest a dedicated library system hosted e.g. by the European Commission which is an independent entity and funding organisation of many ontology-related research projects. Such a system that provides the afore mentioned content and structural search criteria and requirements including project results (the meta model/instances in particular) as well as a meta-data like profile of the relevant information will strongly support reuse efforts.

Addressing the hypothesis that a central ontology library systems is fostering reuse potentials and standardisation in the field of European ontology research results, it is therefore argued that a library system that realizes the before mentioned requirements and is hosted by an independent entity is in fact beneficial for European ontology research. As the concepts for the different ontologies addressing certain domains are content-wise quite closely related and can generally be integrated to form new, broader ontologies at lower cost and effort compared to creation from scratch, the critical point for enabling reuse is content availability and retrieval. For example if an ontology with content relevant for European-wide handling of life-events in public administrations would be generated and available in such a library, each project can build on this ontology and extend it resulting in an increasingly mature and complete ontology with each iteration.

The authors therefore propose activities to be directed to setting up such a central ontology library system that acts as a single point of entry to retrieving existing ontology research results and provides the functionalities elaborated in this paper and the presented prior work on the topic. Further research should be dedicated to the implementation of a prototype that realizes the proposed functionality of a ontology library system in order to evaluate the impact on reuse of ontologies. Subsequently, results of the evaluation need to be incorporated into a refined set of criteria for fostering ontology reuse which can then be implemented on a larger scale hosted e.g. by the European Commission.

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