Towards Semantic Web Portals

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ABSTRACT

A web portal is a platform for information presentation and information exchange over the internet in a community of interest. In order to provide adequate facilities for communication and information sharing, web portals should utilize appropriate technologies. Current web technologies used in web portals present serious limitations regarding facilities for search, access, extraction, interpretation, and processing of information. Thus, support for information sharing and communication in web portals is confined due to limitations in the underlying technologies. Semantic Web technologies have the potential to overcome these limitations, hence utilizing them as grounding technologies will facilitate much more sophisticating web portals. Following this context, the aim of this paper is to expose the idea of Semantic Web enabled web portals. Therefore we present a wide-coverage description framework along with a criteria catalogue in order to indicate possible functional improvements as well as technical requirements for such web portals in detail. Then we relay results of a survey wherein we have examined the utilization of Semantic Web technologies in existing web portals, concluding in future requirements for the development of Semantic Web enabled web portals.

Categories and Subject Descriptors

H.4.3 [**Information Systems Applications**]: Communication Applications – *Bulletin Boards, Information browsers.*

General Terms

Design, Standardization, Experimentation

Keywords

Semantic Web, Web Portals, Community Portals, Semantic Web Applications, Ontologies, Web Services

1. INTRODUCTION

The impressive growth of the internet in the last decade has made a huge amount of information available throughout the world. Various communities have made use of the web to strengthen communication and information exchange, not only within themselves but also with external communities or individual users. For this purpose, miscellaneous web portals have appeared with aiming at providing an open and effective communication forum for their members.

In a prototypical case, a web portal collects and presents relevant information for the community, and users can publish events or information to the community. For supporting this, a web portal should provide facilities for users to locate available information in the portal according to their personal preferences, topics, etc. Further, sophisticated web portals should provide easy-to-use facilities for communication and information exchange between portal users as well as in between different communities of interest [10].

At this point of time, conventional web technologies are used for building web portals. These offer straightforward means for creating and accessing new content on the internet. Nevertheless, current web technologies have serious limitations in making information accessible for users in an efficient manner. A general shortcoming of existing web technologies is that the support for essential information processing facilities like search, access, extraction and interpretation is very imprecise and weak. As these limitations are inherited in web portals, the quality achievable for information exchange and communication support is naturally restricted. Semantic Web technologies [3] aim at overcoming these problems by enabling automated access and processing of information on the web. Ontologies, as the backbone technology of the Semantic Web, provide machine-processable semantics of data and thus enable semantically correct communication and information exchange between different agents (software and people). Furthermore, Semantic Web Service technologies facilitate distributed computation over the internet, combining the advantages of the web as a world-wide information exchange infrastructure with the computational strength of computers and thus turning the web from an information repository for human consumption into a device of distributed computation [8].

Hence, Semantic Web technologies can considerably defeat the shortcomings of current web portals in multiple ways. At first, the elementary information handling facilities of web portals can be improved by applying Semantic Web technologies as the technical basis. Secondly, a new class of functionality can be added to web portals as Semantic Web technologies allow interoperability of web portals and other Semantic Web driven applications. In this sense, Semantic Web enabled web portals (SW portal for short) represent the next generation of web portals. As a preliminary definition we restrict the scope of such portals to the following:

- It is a web portal. A web portal is a web site that collects information for a group of users that have common interests [14]
- It provides facilities for communication and information exchange within a community of interest as well as in between different communities
- It is based on semantic web technologies and utilizes these to provide enhanced web portal facilities.

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The rest of the paper is organized as follows. Section 2 introduces the approach of our SW portal description framework; Section 3 presents a detailed criteria catalogue of the description framework, including technological requirements for SW portals; Section 4 summarizes the results of our survey on existing SW portals and points out the state of the art in SW portals; Section 5 indicates related work; finally Section 6 concludes the paper and proposes future directions.

2. DESCRIPTION SCHEME

This section introduces the approach we have developed for web portal description, especially for SW portals. The aim of this framework is to allow an overall analysis of SW portals with special attention to the usage of Semantic Web technologies.

In general, a web portal is a complex application. For the purpose of an overall description framework we identify three different layers, each of them describing a portal from a different perspective. The first is the **Information Access** layer which describes a portal in terms of its usability, second the **Information Processing** layer for inspecting the information processing facilities of a portal, and third the **Grounding Technologies** layer for investigation of the applied technologies. Figure 1 gives an overview of the layers and their relationships.

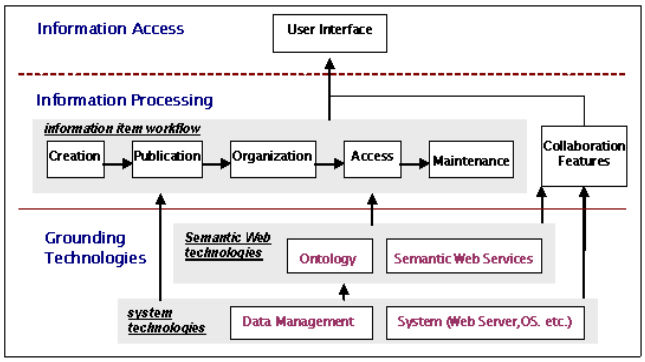

Figure 1: Semantic Web Portal Evaluation Layers

The Information Access layer is concerned with the usability of a SW portal; therefore the user-system-interaction, the maturity of implementation and the quality of information provided by the portal are inspected in this layer. The Information Processing layer covers the information item processing capabilities of a SW portal differentiated by the 5-phase information item workflow as illustrated in Figure 1 (creation, publication, organization, access, maintenance). The aim of the description in this layer is to gain a complete understanding of the processing features and their technical realization for each phase of the information item workflow. Additionally we inspect collaboration features in this layer, which expand information exchange and communication facilities of a SW portal in terms of user collaboration. The lowest layer of the scheme encloses technologies enabling features on the upper levels and hence is referred to as the Grounding Technologies layer. Therein we differentiate System Technologies and Semantic Web technologies: the former covers basic web portal technologies while the latter is concerned with those technologies that make a web portal become a Semantic Web Portal. The next section provides a more detailed explanation of the components introduced in the description scheme.

This layered scheme comprises the relevant aspects for an overall description of web portals. Further it allows a precise analysis of how technologies are utilized, especially pointing out potential functional improvements by using Semantic Web technologies in web portals. It is important to note that the description scheme do not imply a recommended architecture for SW portals. But we aim at describing a SW portal exhaustively from a functional point of view, i.e. portraying its features in terms of a functional analysis. The construction of this scheme has been inspired by previous work on web portals [10] and Semantic Web portals [16].

3. CRITERIA CATALOGUE

In the following we introduce the components of our description scheme catalogue in detail. The aim of this catalogue is two-fold: one the one hand, according to the objective of our description framework, it determines the information needed to provide a full-fledged description of a SW portal. On the other hand, we discuss where and how web portal facilities can be enhanced by applying Semantic Web and Semantic Web service technologies.

The arrangement of the catalogue criteria follows a bottom-up approach. First we portray the description criteria of the Grounding Technologies layer as these underlie the Information Processing features of a SW portal. Then we explain the criteria of the Information Processing layer, and finally the Information Access layer is examined.

3.1 Grounding Technologies

As shown in Figure 1, the Grounding Technologies layer contains the basic technical building blocks of a SW portal. These are the System Technologies and the Semantic Web technologies used in a web portal.

3.1.1 System Technologies

As SW portal is a web application, the first group of description elements are ordinary technologies used in a web application. In order to provide a general overview, a tabular list of the following aspects will be sufficient for describing a SW portal.

3.1.1.1 Web Technology

Architecture. To give an initial overview of the portal, the system architecture is described. Usually this is a common three-tier architecture (data storage, application logic and presentation tier).

Web Server. The web server used as well as other server side technologies are listed.

User Interface Technology. Indication of the UI-technology (static HTML, JSP / ASP, etc.).

3.1.1.2 Data Management

Data Storage. Here the data storage devices are listed (Database, RDF-Repository, etc.) as well as the kind of information that is stored in these (information items, user-data, ontology-data, etc.).

Sorting and Indexing. Sorting and indexing techniques improve the performance on data storing and retrieving. This can be a full text index or other techniques to organize meta-data.

Data Transfer. Description of data formats and transfer protocols used. Here, the transfer between different components as well as between different layers identified in Figure 1 is examined.

3.1.1.3 System Maintenance

System Administration. This includes maintaining information items, user data and ontologies, and tool support for runtime system administrating. Here only the latter are inspected as the maintenance of information items is addressed within the Information Processing layer.

Security Technology. Features to be inspected here are technologies for ensuring safety of information access in the system. These are, for instance, the usage of SSL-connections or password-protection for private areas of the SW.

3.1.2 Semantic Web Technologies

Semantic Web technologies to be utilized in a SW portal are ontologies and Semantic Web Services. The information needed to analyze their usage is listed in the following. Remark that these aspects can also be seen as technological requirements for SW portals.

3.1.2.1 Ontologies

The central components of a Semantic Web Portal are ontologies as they provide term definitions of the domain of interest and machine-readable semantics, enabling enhanced information processing [9]. Ontology techniques can be applied in different ways to enable Semantic Web enhanced functionalities of a SW portal: first as the grounding data model of the portal, second for efficient information item handling, and third for inter-portal information exchange [15].

For describing the ontologies used in a SW portal information the following aspects are required:

Ontology Type. Different types of ontologies are distinguished according to the purpose of their usage [13]. The ontology types mostly used in SW portals are domain ontologies and application ontologies. In addition to the type description the concrete purpose of the ontology usage in a SW portal should be stated.

Ontology Structure. An overview over the ontologies' structure and size is given to accomplish a basic understanding of the ontologies used. Therefore, descriptions of the main concepts are given and the number of ontological notions – concepts, properties, relationships, and axioms – is quoted. If upper-level ontologies are used, they are listed here [12].

Additional Facets. Optionally further features of the ontology can be stated, if important for describing the ontology. Example criteria are internationalization, multilingualism, and balance of expressivity and scalability of the ontology.

3.1.2.2 Inference and Reasoning

Depending on the ontology formalism, inference mechanisms can be used to enhance the processability of ontology data. For example, a reasoner can be used to check cardinality constraints and class membership or an inference engine could interpret symmetric or transitive relationships. As for ontology-based applications in general, this is not a required feature for SW portals but it is likely in order to improve information processing quality.

3.1.2.3 Ontology Management

The final aspect for describing ontology usage in SW Portals is Ontology Management, i.e. techniques for administrating ontologies. As ontologies are the central component of SW portals, appropriate ontology management facilities are essential for long-term usability of the portal. The aspects enumerated below represent the general requirements for Ontology Management. These criteria were identified for ontology library systems in [7]; we adapted them slightly to the requirements for Ontology Management in SW portals.

Editing. An appropriate editing facility for ontologies has to be provided. This can either be an ontology editor, e.g. PROTÉGÉ [1] or OntoEdit [2], or an editing facility integrated in the portal.

Ontology Search for Administration. To facilitate management of several or huge ontologies in a SW portal, appropriate support for finding a specific ontology or a part of an ontology is required. This can be realized by a search on textual descriptions of an ontology or by (internal or external) means for ontology browsing.

Maintenance / Versioning. An ontology is a static representation of knowledge structures. As the domain of a SW portal may change over time, the ontology should be updatable. Therefore ontology versioning techniques should be employed which allow tracing of changes by enumerating different ontology versions [15].

Standardization / Interoperability. A major advantage of SW portals is that Semantic Web technologies can be applied to achieve interoperability and information exchange with other SW portals and Semantic Web applications. Therefore a SW portal should support the standard Semantic Web ontology languages (such as RDF, DAML+OIL, and OWL), provide functionalities for export and import for these, and employ means for integrating ontologies [22].

3.1.2.4 Semantic Web Services

Web Services add a new level of functionality on top of current web, transforming the web from a source of distributed information to a distributed source of functionality. Current research initiatives are concerned with enriching web services using semantic information in order to allow automatic location, composition, invocation and interoperation, bringing the new concept of Semantic Web Services [5], [8]. The use of Web Services and Semantic Web Service technologies in a SW portal has to considered as it reflects to what extent a SW portal exposes its functionality as services accessible over the Web. Therefore the following aspects have to be inspected.

Functionality. The different functionalities available on a SW portal – e.g. content search, content publication, etc. – can be made accessible as web services. The degree of functionality exposition via web services determines to what extent a SW portal can be used not only through its user interface, but also programmatically. To describe the degree of web service usage, a relation between the portal functionalities accessible through its user interface and those accessible through web services is requested.

Semantic Web Services. Enriching web services with semantic information allows automatic location, composition, invocation, and interoperation of services. Therefore not only the portal functionality exposed through web services must be considered, but also to what extent these services include automation support.

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[1] see: http://protege.stanford.edu

[2] see: http://www.ontoprise.de

3.2 Information Processing

Based on the descriptions of the Grounding Technologies, this layer exposes the description criteria for a functional analysis of the information processing features of a SW Portal.

As an analysis framework for the Information Processing layer we utilize the "Document Life Cycle" as a starting point. The Document Life Cycle has been defined for intranet document management systems and identifies 5 stages: creation, publication, organization, access and destruction / maintenance [11]. We adapted this model as to describe the information item life cycle in SW portals.

In the following we explain every step in more detail and confer the tool support a SW portal should provide for each stage. The description of a stage comprises a functional explanation, the applied technologies of the Grounding Technologies layer, and the accessibility of the processing feature (visitor, membership user, administrator). The aim of the analysis in this layer is to point out where and how Semantic Web technologies can be used to enhance information processing capabilities of the SW portals.

3.2.1 Creation

The first stage of the information item life cycle in a SW portal is the creation of a new information item. That is, a user produces a new information item that he wants to add to the portal. Usually the item created is an ontology object, so the user implicitly creates an instance of a given ontology concept. Thus, the assignment of the information item to the ontology is already done in this stage. This phase is supported by providing appropriate editing forms or similar means of gathering the necessary information for the concrete information item, which should be based on the underlying ontology.

3.2.2 Publication

The next step after creating a new information item is to publish it in the SW portal. The point of interest here is to examine how a new information item is made accessible to the community. In general this is achieved via establishing different user rights to control the quality of the information published, so improvements by using Semantic Web technologies in this phase are narrow.

3.2.3 Organization

This phase is concerned with storing and indexing information items in the portal's storage devices which have already been described in System Technologies section. Here, the technique for storing ontologically annotated information items is of interest: a SW portal should allow retrieval as well as import and export of ontology data in order to provide information exchange with other Semantic Web applications. It is not recommended to use specialized ontology repositories, but information items have to be retrievable with the same ontological annotations that have been assigned during creation.

3.2.4 Access

In this phase the retrieval functionalities for the information items of a SW portal are described, i.e. how the user can access the published information. Mainly search facilities are described. The major interest in this phase is to analyze the usage of Semantic Web enhanced search in a portal. As empirically proved in [1] and [21], Semantic Web enhanced search accomplishes significantly better search results than other information retrieval techniques.

For analyzing the access features of a SW portal we distinguish the following types of search facilities, ordered according to the usage of Semantic Web technologies (inference-powered search is the one exploiting to a greatest extent these technologies):

1. key word search
2. ontology browsing
3. ontology search
4. inference-powered search.

3.2.5 Maintenance

The last step of the life cycle model comprises maintenance of information items already stored in the system. To permit long term usability of a SW portal, it should be possible to modify information items, update or move them if there are changes in the content or in the ontology schema, or delete them if they got irrelevant. For analysis purpose, appropriate ontology versioning mechanisms as mentioned above should be applied in SW portals.

3.2.6 Collaboration Features

Besides the information item life cycle model we further consider collaboration features in the Information Processing layer. By this we mean additional features that support information sharing and communication between users of the portal, e.g. mailing features or discussion forums, or multiple user editing facilities for information items as a Semantic Web enabled feature. This kind of collaboration tools is important for SW portals because they add surplus value for the community of interest that uses the portal.

The collaboration features offered may vary heavily in different SW portals. Thus a listing with short descriptions of available collaboration features of a SW portal will be sufficient for the purpose of our analysis.

3.3 Information Access

This layer describes a SW portal in terms of a usability-evaluation from the user perspective and the quality of information provided in a portal. These aspects are not directly connected to the technical realization, but they are important criteria for an overall description of a SW portal because they determine the acceptance and use of the portal in the first place.

3.3.1 Usability

The first aspect to be considered in this layer is the usability of a SW portal. Usability addresses the relationship between a portal and its users by inspecting if a system is easy to understand, easy to use, easy to remember, error tolerant, and subjectively pleasing [6]. Usability depends on a number of factors including how well the functionality fits to user needs, how well the system workflow fits user tasks, and how well responses fit user expectations. For analyzing these aspects, we refer to commonly used heuristic inspection methods for usability of IT-systems [18]. We consider the aspects mentioned in the following as most relevant for usability evaluation of SW portals. [3]

Maturity of Implementation. This refers to the completeness of the implementation in a SW portal. All functionalities accessible through the user interface should properly operated without errors or broken links. Further, a sufficient error handling should be

[3] see a listing and discussion of heuristic criteria for usability at: http://www.useit.com/papers/heuristic/heuristic_list.html

provided in order to precisely indicate the problems and suggest a solution. The maturity of implementation is also a criterion to show the stage of realization in using Semantic Web technologies.

Personalization and Communication. One of main merits of web community portals is that users can customize the portal functionalities according to their personal convenience, thus improving the effectiveness of a portal for the user. Herein we distinguish personalization for single users and collaborative personalization, i.e. facilities to build a virtual meeting room for a subgroup of portal users that makes communication channels available. These functionalities are usually realized as private, access-restricted information spaces whereby semantic mark-up is especially helpful to facilitate information exchange embedded in the midst of the interaction between community users.

Help and Documentation. In order to allow a broad group of users using a SW portal, appropriate help and documentation should be provided. A help facility should be easy to understand, focused on users' tasks, list concrete steps to be carried out, and not be too large. A site map will be helpful to grasp the whole functionalities of the portal and the brief description of semantic processing or ontology structure is essential to understand its semantic capabilities.

However, SW portals are a special breed of web applications as they offer a blend of information, applications and services. Thus, for describing a SW portal's usability, additional, more general issues have to be inspected. Most important are the following: packaging, structuring, integrating and organizing information and knowledge provided to their user community [19].

3.3.2 Quality of Information

The second aspect to be analyzed in the Information Access layer of our description framework is the quality of information provided in a SW portal. This is important because users expect to find all information related to a field of interest in a valuable SW portal (coverage) and they also expect these information to be trustworthy for their purpose of usage (reliability).

Coverage. A SW portal should provide all information that is relevant for its user community. This is described by assessing the Relevance and the Completeness of information offered in a SW portal, which are analyzed in terms of the width and the depth of information items in a SW portal. The width of coverage is related to the scope of the portal while the depth of coverage is related to relevance regarding the content of information resources. Broad coverage in depth and width affect effectiveness and uniqueness of a SW portal and thus determines user satisfaction. Further, information in a SW portal should be semantically consistent so that users do not have to deal with ambiguous terminology inside a SW portal.

Reliability of Information Resources. Information provided by a SW portal should be reliable in the sense that a user can rely on them as correct, usable, and up-to-date information. Therefore information items should be assigned with descriptive meta-data like owner, authors and their affiliation, creation and modification date, etc. Further, the image of the portal should be inspected as this is strongly connected to its reliability.

4. EVALUATION OF SW-PORTALS

After having introduced our framework for describing SW portals, this section summarizes the results of an evaluation we have performed on existing SW portals.

For our evaluation we have utilized the description framework to portray the portals on the one hand and on the other to assess them according to the requirements on SW portals as stated in the description criteria catalogue. The aim of this evaluation is to detect the state of the art in realization of SW portals and to position existing initiatives within the idea of Semantic Web enabled web portals sketched out in this paper – i.e. utilizing Semantic Web technologies in web portals to support enhanced web portal facilities and to enable interoperability with other Semantic Web applications.

At this point of time there are a lot of web portals that make use of Semantic Web technologies in one way or the other. However, some of them can be seen as prototypical solutions with regard to the idea of SW portals presented here. In this regard we chose two academic efforts (Esperonto Portal, OntoWeb Portal) and two efforts of commercial companies (Empolis K42, Mondeca ITM) for a detailed investigation. Thereby we intended to identify the applicability of SW portals in non-profit as well as in commercial application areas. A summary of the evaluation results on these SW portals is given below. Other SW Portals we inspected are: the SWWS portal[4], the Mindswap portal[5], KA2[6], parts of the AIFB portal[7], the KAON portal[8] and the OntoWebEdu portal[9]. These have evaluated in detail because they only make use of Semantic Web technologies to a very low extent and thus can not be considered as a prototypical SW portal.

4.1 Inspection of existing SW Portals

In the following we present the results of evaluating the four SW portal initiatives that we have investigated in detail. Here, we only highlight those features of each portal that are most relevant for positioning the effort as a SW portal. The detailed evaluation can be found in our technical report. [10]

4.1.1 Esperonto Portal

The Esperonto Portal is developed by the Ontology Group at Facultad de Informática, Universidad Politécnica de Madrid (UPM). [11]

It serves as the intra- and extranet platform for the EU project Esperonto, i.e. for making information related to the Esperonto project available to project members as well as to the public. The portal relies on 5 highly interconnected ontologies, each of them covering one relevant aspect for R&D-projects. The technical foundation of the portal is WebODE, an ontology engineering workbench developed at UPM that provides basic features for ontology-based applications like storage and retrieval, edition, import and export of ontology data [2]. The Esperonto portal is based on ODESeW, which is built on top of WebODE and provides functionalities for presenting, editing, querying and maintaining ontology-data via a web interface, also referred to as the "knowledge portal generator" [4]. These components provide

[4] http://swws.semanticweb.org/

[5] http://owl.mindswap.org/

[6] http://ka2portal.aifb.uni-karlsruhe.de/

[7] http://www.aifb.uni-karlsruhe.de/Personen/

[8] http://kaon.semanticweb.org/

[9] http://qmir.dcs.qmul.ac.uk/ontoweb/index2.html

[10] http:// HOLGER

[11] http://www.esperonto.net/

basic solutions for ontology-management, but not realized to the extent requested for SW portals in to our description criteria catalogue. Especially, the integrated WebODE ontology editor is not powerful enough for high-quality editing, the versioning mechanism is very basic and there is no support for web services. The Information Processing features of the Esperonto portal are realized following the way proposed above, but they are not very mature. The ontology-based search does not work properly, maintenance facilities are very weak, and the information presentation is not satisfactory from the usability point of view.

Summarizing, the Esperonto portal realizes the basic requirements for Semantic Web enabled web portals, but it does not attain a sophisticated level in ontology management and usability.

4.1.2 OntoWeb Portal

The OntoWeb Portal is a community portal for academic and industrial partners interested in the Semantic Web. It has been set up as part of the EU project OntoWeb (IST-2000-29243). [12]

The portal is built up on the ZOPE Application Server and the Content Management Framework (CMF) [13]. These components cover all the data management of the portal, chosen to achieve high performance and scalability. The second building block is the OntoWeb Ontology, a light-weight ontology (its maximum depth is 4 levels; the properties mainly consist of DC-elements[14] with a few extensions). It defines meta-data for all content types available in the portal and all information items in the portal are treated as ontology instances. As a static, non-evolving ontology is sufficient for this purpose, the ontology management in the OntoWeb portal is very weak (there is no versioning, no editing support for the ontology schema; a RDF-export-facility has been added in the latest portal version, but import is not supported). The OntoWebEdu portal (s.a.) relies on the OntoWeb ontology as its grounding data model, as a first step towards interacting SW portals. Regarding the Information Processing layer, the support for the information item life cycle is elaborated to a very extent also the usability and quality of information is very high.

In conclusion, the OntoWeb portal is a very mature portal from the users' perspective. But the usage of and support for Semantic Web technologies does not apply to the requirements for SW portals in terms of our framework.

4.1.3 Empolis K42

K42, developed by Empolis GmbH, is a knowledge management product that offers a basic infrastructure for handling Topic Map data whereon web portals can be build. [15]

The core of the SW portal technology is the K42 server which provides basic management facilities, i.e. storing, querying, and maintaining for Topic Map data on basis of a self-defined Topic Map model. Topic Maps are a standardized technique for meta-data representation [16], in terms of expressiveness comparable to RDF [17]. Further, the K42 system comprises three tools: WebAuthor, TopicMapView, and Ontogen. The latter is an end user tool to visualize Topic Maps; the other two provide support for creation, publication and maintenance of Topic Map data. This tool suite provides basic functionalities for handling semantically annotated information in a web application, SW portal facilities have to be developed on top of this. Although a demonstration portal has been available[17] we will not discuss the Information Processing and Information Access layer here since they are not part of the K42 product.

With the K42-system, Empolis offers an easy-to-use and scalable basement for SW portals, using Topic Maps for ontology representation. As its facilities for handling and managing ontology data are very basic, it cannot be regarded as a sufficient SW portal technology within our framework.

4.1.4 Mondeca ITM

The Intelligent Topic Manager (ITM) developed by Mondeca is a tool designed for knowledge management and automated knowledge acquisition, based on semantic technologies. [18]

Similar to the other SW portals, the core of ITM is a backend-application that supplies the basic ontology data management (note that there is no storage device supported by default, it has to be connected by portal developers) as well as an ontology that defines meta-data for information items. In addition, ITM offers an extensive tool suite that is customizable for individual SW portals. It comprises the ITM Editor for editing and importing ontologies (supported standards: Topic Maps and OWL), a web-frontend template including a graphical visualization for ontology data, semantically driven querying, and a knowledge acquisition tool using Information Extraction techniques. By this, the ITM allows building SW portals with a high degree of usability, but the usage and support for Semantic Web technologies still is deficient as versioning is not supported, the ITM Editor is not powerful enough for sufficient ontology editing, and export or imports of ontologies is not supported.

Thus, the Mondeca ITM can be rated as a satisfying development framework for SW portals. Similar to the other portals inspected, the ITM technology does not support ontology management and web services in a way that enables enhanced SW portal features like interoperability and information exchange between different Semantic Web applications.

4.2 Evaluation Results

In general we conclude that all the SW portal initiatives inspected in detail provide SW portal functionalities and features to some extent, but none of them can be observed as a sufficient solution with regard to the idea of SW portals presented in this paper.

Regarding the Grounding Technologies layer of our framework, all portals use ontologies as the grounding data model in the sense of an application ontology and support ontology representation standard like RDF, OWL, or Topic Maps. But none of the portals provides satisfying means for ontology management; neither does any portal provide its functionality as Semantic Web Services, thus there is no support for evolvability and interoperability of SW portals and with other Semantic Web applications yet. This hampers the exploitation of the functional benefits of Semantic Web enabled applications, which arise in interoperability and interchangeability of applications on data. Further, none of the

[12] http://www.ontoweb.org

[13] Open source components offered by ZOPE Cooperation, see http://www.zope.org.

[14] Dublin Core, meta-data standard, see: www.dublincore.org

[15] http://www.empolis.com/. Emplois changed its portfolio during our evaluation: the K42 development has been integrated within the e:kms knowledge suite.

[16] ISO/IEC-Standard 13250, see http://www.topicmaps.com/

[17] http://62.231.133.220/xmlus02-nav/index.html

[18] http://www.mondeca.com/english/produits_services.htm

initiatives uses inference or reasoning techniques for enhanced ontology data handling.

The evaluation of the Information Processing layer points up that most SW portals implement the information item life cycle in the way we have proposed, or at least follow this direction. That is support for creating information items with instant assignment as ontology instances, quality-assurance for publication via different user roles, ontology-enhanced access features, and tools for information item management.

It is to note as a very significant drawback that collaboration features, although considered to be very important in terms of the surplus provided for users, are not provided by any of the SW portals surveyed. In terms of usability, the OntoWeb portal as well as the ITM-template can be regarded as prototypical solutions. Only the OntoWeb portal offers high quality of information. The reason for this is that it is only portal surveyed that is actually used by a sizable community.

5. RELATED WORK

Although increasing efforts are to be recorded in surveying ontology-based applications from various aspects, no study can be found on describing and evaluating Semantic Web enabled web portals. Hence we present efforts done before that have various links to the work presented in this paper and we relate them to our work.

The advantages of the web and especially of web portals as entry points for information exchange and communication have been depicted before. The work on the usability of web portals for governmental services by Gant and Gant [10] has outlined this, the design guidelines for information-abundant web-sites by Sheidermann [19] point out the difficulties in creating user-friendly information portals on the web.

Ding and Fensel [7] conducted an extensive survey on ontology library systems which includes almost all the existing ontology library systems. The focus therein is ontology management, which has been determined as a key part of SW portals. Based on this work we have derived the criteria for ontology management in our description framework.

Maedche et al. [16] proposed a generic approach for developing semantic portals, *viz.* SEAL (SEmantic portAL), that exploits semantics for providing and accessing information at a portal as well as constructing and maintaining the portal. Although the focus of that work is different from the one followed in this paper, we received valuable input for the design of our description framework. We extended their proposal by including further aspects or requirements, respectively, that we believe are relevant in order to achieve a full-fletched description framework for SW portals. More precisely, our work adds the following aspects: functional ontology management (editing, versioning, and interoperability support), Semantic Web Services, ontology-powered search, the information item life cycle model for describing a portal's information processing features, and the Information Access layer.

So from our point of view, our work presented in this paper is quite unique with the respect to the broad coverage of the description framework and the positioning of existing SW portals provided.

6. CONCLUSION AND FUTURE WORK

In this paper we have sketched a vision of Semantic Web enabled web portals, SW portals for short, as a future breed of entry points for communication and information exchange over the internet. Therefore we have developed a description framework that aims at portraying SW portals with all their relevant facets and we presented the results of an evaluation of existing SW portals in order to determine the stage of affairs in SW portal development.

The idea of Semantic Web enabled web portals is that web portal facilities can be improved significantly in various aspects by using Semantic Web technologies. The main benefits are that, on the one hand, ontology techniques allow structuring a web portal as well as handling and presenting large amounts of information in a more decent way than conventional technologies. On the other hand the employment of Semantic Web technologies enables web portals to interoperate with other Semantic Web applications, whereby ontologies allow semantically consistent interchange of information and Semantic Web Services enable interchange and reuse of functionality. While the former aspect is related to improvements of functionalities already provided by web portals, the latter establishes a new field of web portal facilities.

In order to allow an overall description of Semantic Web enabled web portals we developed a framework, consisting of three layers whereby each layer is intended to examine a SW portal from a different perspective. The Grounding Technologies layer depicts the underlying technologies used in a portal, especially the Semantic Web technologies applied. The Information Processing layer inspects the information processing features of a SW portal with particular respect to how the grounding technologies are employed, and the Information Access layer is concerned with the usability of a SW portal and the quality of the information provided. We discussed the description criteria exhaustively because they do not only serve as a scheme for describing a SW portal, but the also imply technological requirements that are oblige in order make the vision of interoperable SW portals become reality.

Further, we utilized our description framework for evaluating existing portals with the aim of positioning current efforts with respect to the idea of SW portals delineated above. The most important outcome of the detailed survey on the existing SW portals briefly outlined in this paper is that SW portals are still at their very early stages. The portals inspected implement Semantic Web technologies only in a very basic way, i.e. using ontologies for structuring and handling information, but they do not provide sufficient support for ontology management nor for Semantic Web Services in order to enable interchange and interoperability.

Thus we have to conclude that current efforts around SW portals are not mature enough to enable evolving and interoperating web portals that could serve as advanced information repositories for communities of interest as well as for Semantic Web applications. Because of this, we finalize our work by pointing out future development requirements that we believe are necessary to build successful SW portals:

- Semantically Enhanced Information Management

  Ontology techniques should be applied for information management to a higher extent as they allow structuring, handling, searching, and presenting of information in a better way than conventional web technologies.

Inference-based facilities for ontologies should be adopted.

- Advanced Ontology Management:

  Decent Ontology Management technologies should be incorporated in order to facilitate the advanced features of SW portals. Thus techniques for (multiple user) editing, ontology versioning, import and export standardized have to be further developed.

- Semantic Web Services

  SW portals should offer their functionalities as Semantic Web Services in order to allow interchange and reuse of functionality between SW portals and other Semantic Web applications.

- Interoperability

  Reuse of existing information and functionality as well as information interchange and cooperation in between SW portals should be considered when designing a SW portal.

- Enhanced Web Portal Facilities

  Collaboration features and other user-orientated facilities that increase the usability of a SW portal should be provided to provide a profitable place for information sharing and communication from the users' perspective.

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