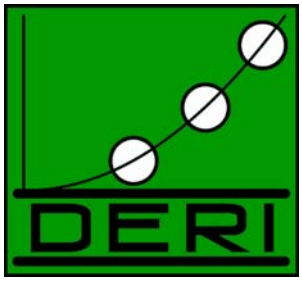

Semantic Web Portals – State of the Art Survey

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Abstract

Web portals are entry points for information presentation and exchange over the internet used by a community of interest. Therefore they require efficient support for communication and information sharing. Current Web technologies employed to build up these portals present serious limitations regarding facilities for searching, accessing, extracting, interpreting and processing of information. The application of Semantic Web technologies has the potential of overcoming these limitations and will lead to semantically enhanced Web portals. This paper presents the state of the art application of Semantic Web technologies in web portals and the improvements achieved by the use of such technologies.

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1 Introduction

The World Wide Web (WWW, or the Web for short), has made a huge amount of information electronically available, and is an impressive success story in terms of both available information and the growth rate of human users [11]. The Web has evolved from an in-house solution for around 1000 users in 1990 to more than 1 billion users and more than 1 billion documents (on the surface web[1]), not only world-wide but also device-wide. This success has been based mainly on its simplicity, giving software developers, information providers and users easy access to new content. Nevertheless, the same simplicity that made the impressive expansion of the Web possible has brought important, and in some cases critical, drawbacks that are hampering a further development of the Web.

So far, various communities have taken advantage of the current Web functionalities to strengthen communication and information exchange not only within the community but also with external communities or individual users. Miscellaneous web portals have appeared with the purpose of providing an open and effective communication forum for their members. In a prototypical case, a portal collects and presents relevant information for the community, and users can publish events or information to the community. Portals provide facilities for users to locate interesting information in the portal according to their personal preferences, topics, etc. In some cases, users with common interests can build their own specific community inside the general community to submit and share information about a given topic.

Nevertheless, current Web technology presents serious limitations to make information accessible for users in a efficient manner. The general problem to find information on the Web is summarized in [7]: searches are imprecise, often yielding matches to many thousands of hits. Moreover, it is not possible to directly retrieve a particular piece of information, instead users have to read through all retrieved documents and identify the information manually. These limitations naturally appear in existing Web portals based on this technology, making information searching, accessing, extracting, interpreting and processing a difficult and time-consuming task.

In this context, the **Semantic Web** [19] enables automated information access and use based on machine-processable semantics of data. **Ontologies** are the backbone technology for the Semantic Web and - more generally - for the management of formalized knowledge in the context of distributed systems. They provide machine-processable semantics of data and information sources that can be communicated between different agents (software and people). In other words, information is made understandable for the computer, thus assisting people to search, extract, interpret and process information.

Therefore Semantic Web technologies can considerably improve the information sharing process by overcoming the problems of current web portals. In this sense,

[1] If we consider pages generated dynamically and not found by traditional search engines (the deep Web), the number of available documents was estimated to be around 550 billion already three years ago [4].

portals based on Semantic Web technologies represent the next generation of web portals.

In this paper we investigate the state of the evolution of web portals and survey existing portals that make use of Semantic Web technologies. The scope of portals investigated is restricted to Semantic Web portals (SW portal for short), which are defined as follows:

- It is a web portal. A web portal is a web site that collects information for a group of users that have common interests [17]
- It is a web portal for a community to share and exchange information
- It is a web portal based on semantic web technologies.

The aim of this paper is to compare existing SW portals regarding their features and underlying technologies in order to identify their strengths and weaknesses. A general purpose of our investigation is to show to what extent Semantic Web technologies are applied to portals at this point of time and which potential benefits these technologies have been realized so far.

The paper is structured as follows: Section 2 presents the evaluation approach followed in the survey; Section 3 details the criteria used for our evaluation approach; Section 4 uses the criteria catalogue defined before to evaluate existing SW portals; Section 5 analyzes the survey results and provides a comparison between these portals; Section 6 indicates related work and Section 7 concludes the survey and points out the future work. In addition we give a brief comparison of the survey results in tabular form in the Annex.

2 Evaluation Scheme

This section introduces the approach pursued for describing and evaluation of Semantic Web Portals. We present an evaluation scheme that allows an overall analysis of a SW portal.

As mentioned above, in the context of this survey a SW portal is understood as a web site that provides information and exchange facilities for a community of interest based on the use of Semantic Web technologies. Figure 1 shows the scheme that is utilized for describing and evaluating SW portals in this paper. It mainly distinguishes three layers: **Information Access** from the user's perspective, **Information Processing** features of the portal and the **Grounding Technologies**. The distinction into three layers is inspired by the three tier architecture used in software engineering to construct information systems. The layers are separated by a solid line. In the three layer architecture each layer is encapsulated by defined interfaces from the lower layer, thus allowing the usage of its functionality without the need to understand its implementation details.

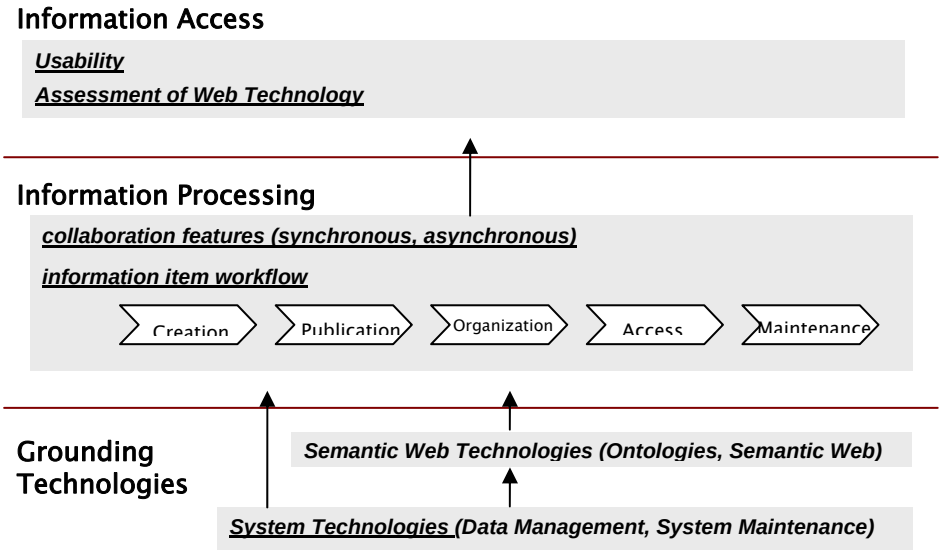

Figure 1: Semantic Web Portal Layers

In the evaluation we take a functional perspective on these layers. The gray boxes group different aspects, arrows denote the interdependence respectively the information flow between the different components. The information item workflow will according to the single work flow steps.

Grounding technologies are comparable with the so called resource or persistence layer [2]. Within information processing this layer is accessed to retrieve data in the portal such as a PDF document and associated metadata. We further divided this layer into system technologies and semantic web technologies. The former are the currently established technologies such as database systems; for the evaluation we looked at the aspects on how data management and system maintenance is done from a functional perspective. Secondly Semantic Web technologies are part of the grounding layer. Semantic web technologies use system technologies, but also the information processing is partly accessing them directly besides using Semantic Web technologies.

The information processing layer is similar to the application logic layer in [2]. For the evaluation we again take a functional view and analyze the steps involved in the information item workflow which are depicted in Figure 1. Due to the importance to establish communication between the portal users community features will be analyzed separately.

3 Evaluation Criteria Catalogue

In the following we introduce each component of our evaluation catalogue and give a brief description of it. The evaluation order follows a bottom-up-analysis: The Grounding Technologies are described first, followed by the Information Processing features, 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 System Technologies and Semantic Web technologies used in the portals.

3.1.1 System Technologies

For evaluation of an SW portal tabular information on used technologies are provided, followed by a more detailed description on data management and system maintenance techniques. By this description of the underlying system technologies an overall functional understanding of the system shall be attained. For this purpose no complete technical analysis is required, but some precise information on the following aspects.

Data Management

Data Storage. This comprises aspects of data storage in a SW portal. Especially data storage devices (Database, RDF-Repository, etc.) and the kind of information that is stored in these (information-items, user-data, ontology-data, etc.) are of interest.

Sorting and Indexing. Sorting and indexing techniques improve the system's data storing and retrieving capabilities. This can be a full text index on stored documents or other techniques to organize meta data.

Data Transfer. This aspect comprises data formats and transfer protocols used in the system. We examine the transfer between the different components as well as between the different layers identified in Figure 1.

System Maintenance

System Administration. Administration of a SW portal includes maintaining information items, user data and ontologies applied in the system as well as tool support for administrating the system at runtime. Here only the administrating options for the system are inspected as the maintenance of information items will be addressed within the Information Processing layer evaluation.

Security Technology. Features to be inspected here are technologies for ensuring safety of information access to the system. For instance, the employment of SSL-connections or password-protection for private areas of the SW portal is considered.

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.

Ontologies

Central components of a Semantic Web Portal are ontologies. An ontology provides term definitions of the domain of interest and it can be applied in different ways to enable Semantic Web enhanced functionalities of a SW portal [20]. For describing the usage of ontologies in a SW portal is based on the following aspects.

Ontology Type. Different types of ontologies are distinguished according to the purpose of their usage. The most common ontology types used in SW portals are domain ontologies and application ontologies [12][15]. In addition to the ontology type description the concrete purpose of ontology usage in a SW portal will be stated.

Ontology Structure. An overview over the ontologies' structure and size is given to achieve a basic understanding of the ontology used [13]. Therefore natural language descriptions of the main concepts are given and the number of ontological notions – concepts, properties, axioms – is quoted. If the ontology uses upper-level ontologies, they are listed here.

Additional Facets. Optionally, further features of the ontology can be stated if they are important to understand this ontology usage in a SW portal. Example criteria are internationalization, multilingualism, and balance of expressivity and scalability of the ontology.

Inference and Reasoning

Depending on the ontology formalism different mechanisms can be used to enhance systems usability. For example a reasoner can be employed to check cardinality constraints and class membership or an inference engine could interpret symmetric or transitive relationships.

Ontology Management

The last aspect for evaluating ontology usage in SW Portals is Ontology Management, i.e. techniques for administrating ontologies. As the ontology is the central component to enable Semantic Web Portals, appropriate ontology management facilities are essential for long-term usability of the portal. The aspects enumerated below are based on the requirements for ontology library systems identified in [7]. These requirements must not only hold for a single ontology, but also and especially for a network of multiple ontologies [18].

Editing. An appropriate editing facility has to be provided. This can either be an ontology editor like PROTÉGÉ [2], OntoEdit [3], or an editor facility integrated in the portal.

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. This can be achieved by ontology versioning techniques which allow to track changes by enumerating different ontology versions. Furthermore the system should provide means of keeping the relation between the schema and the instances consistent, in case of a change to the one or the other. For example support is needed to update instance data automatically in case a property is added to the corresponding instance, this can be for example achieved by sending an email to the owner of the specific instance data that needs to be updated.

[2] see: http://protege.stanford.edu
[3] see: http://www.ontoprise.de

Ontology Search for Administration. In order to facilitate management of several or huge ontologies in a SW portal, appropriate support for finding a specific ontology or a specific part of an ontology is necessary. This is different to the search functionality within the information life cycle (access), which is more end user oriented and hides in particular the technical details of the ontologies which are necessary in the context of Admistration.

Standardization / Interoperability. In order to enable interoperability and information exchange with other SW portals and Semantic Web applications the ontology management system of a SW portal should support Semantic Web ontology languages and provide export / import functionalities for these. Syntactical interoperability is the first step towards an semantic one – enabling sharing of dynamically evolving ontologies in an peer to peer fashion.

Semantic Web Services

Web services add a new level of functionality on top of current web, transforming the Web from a distributed source of information to a distributed source of functionality. Current web service technologies around UDDI[4], WSDL[5] and SOAP[6] provide very limited service automation support. In this context, Web Services are enriched using semantic information in order to allow automatic location, composition, invocation and interoperation, bringing the new concept of Semantic Web Services [10]. The use of web services and the use of semantic technologies to enhance these services must be evaluated as it reflects to what extent a given portal exposes its functionality as services accessible over the Web. Thus, the following aspects are evaluated:

Functionality. The different functionalities available on a SW portal – e.g. content search, content publication, etc. – can be made accessible by using web service technologies. The degree of functionality exposition via web services determines to what extent a portal can be used not only through the user interface, but also programmatically. Thus, a comparison between the portal functionalities accessible through its user interface and the ones accessible through web services is related.

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.

3.2 Information Processing

Based on the evaluation of the Grounding Technologies layer this section exposes the evaluation criteria required for a functional analysis of the information processing features of a Semantic Web Portal.

3.2.1 Information Item Workflow

[4] http://www.uddi.org
[5] http://www.w3.org/TR/wsdl.html
[6] http://www.w3.org/TR/SOAP/

As an analysis framework for describing the Information Processing layer we take the "Document Life Cycle" as a basis. This has been defined for intranet document management systems and identifies 5 life cycle stages: creation, publication, organization, access and destruction / maintenance [12]. This model can easily be adapted for information items in SW portals. The following explains each stage in more detail and presents the related tool support a SW portal should include for these stages. In order to analyze information processing features the following aspects are examined for each of them:

- functional description
- applied technologies of the Grounding Technologies – layer
- Accessibility (visitor, membership user, SW portal administrator).

The aim of this analysis is to point out the usability of Semantic Web technologies in order to enhance information processing capabilities of the SW portals.

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.

Publication

The next step after creating a new information item is to make it accessible to the community. The major interest for functionally analyzing a SW portal with regard to its publication capabilities is analyzing how a new information item is made public. In general this is achieved via establishing different user rights to control the quality of the information published.

Organization

This phase comprises the capabilities for storing and indexing information items in the internal storage devices described in section 3.1.1.

Access

This phase contains the retrieval functionalities for the information items of a SW portal, i.e. how the user can access the published information. Mainly search facilities are described. The major interest for the access aspects is to analyze the usage of Semantic Web enhanced search. As empirically proved by [1] and [25], Semantic Web enhanced search accomplishes significantly better search results than other information retrieval techniques.

For evaluating the search capabilities 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.

Maintenance

The last step of the life cycle model is concerned with 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, or delete them if they got irrelevant. For analysis purpose, the information item maintenance options for users and the SW portal administrator are exposed. These maintenance features are more abstracted then the direct ontology management by means of an application dependent user interface which is specific to the information item that will be modified.

3.2.2 Collaboration Features

Besides the information item life cycle model we further consider collaboration features in our functional SW portals analysis framework. These features facilitate the building of virtual groups – communities of interest and provide support for creating concrete output, such as information items that can be accessed by the community. As starting point we have looked at the research carried out in the area of groupware, but for community portals we have to note the differences between groups and communities [23], illustrated in Table 1.

	Group*		**Community**
Size	Small	↔	Big
Degree of interaction	Tight	↔	Loose
Motivation / Orientation	Common goal	↔	Shared Interest
Objectives of Work	Defined and Shared Objectives	↔	Occasional Information Exchange
Personal Relationship	Individuals know each other on a personal base	↔	Individuals don't know each other
* Groups have usually a defined inner structure and administrative regulations			

Table 1: Distinction between a Group and a Community [23]

Thus we do not expect to include all possible existing groupware features in semantic portals, but certain aspects. However our evaluation has shown that the potential of this aspect is currently not used in the evaluated portals.

For evaluation we adopt the classification into two primary dimensions used in the groupware research [9]:

- time - weather users are working together at the same time (synchronous vs. asynchronous)
- space - weather users are working together at the same place (collocated/face-to-face vs. distance)

Within the context of this paper we assume users are distributed, thus the space dimension can't be used for further classification. Since the possibilities for collaboration are constantly evolving with changes in both our patterns of social interaction and the technology that is available, there is no further widely accepted classification.

In the scope of this survey the following possible components that facilitate community processes are relevent: **Synchronous** collaboration can be achieved via chat systems that are integrated into the portal and linked to special topics or documents. Furthermore the community of a portal can be strengthened by the use of collaborative writing features such a common whiteboard area where multiple users can manipulate the display at the same time.

Asynchronous features are usually more prominent, since they don't put the burden of a precise trimming on a distributed community, even though the social binding effect generated by them is less intense. Email represents the most commonly used feature. It can be integrating by providing email addresses in personal profiles as a starting point for one-to-one communication or via support for mailing lists, which can be used to distribute information. News Groups and Discussion Forums fall into the same category, but they use an on-demand methodology, rather then the interrupt driven methodology of email distribution lists.

Online group calendar systems, which are well known in groupware systems can also contribute to the community collaboration. First they can be used to coordinate synchronous communication events in the community, such as a chat or a conference, but also to deliver information about important time related information such as a work plan or special events of interest.

Another category are data driven collaboration features, such as an expert finder a task or issue tracking system for projects might be considered as extension to an information portal.

Despite this categories it is important to notice that each single feature mentioned before needs adoption from a single user interface to a more community aware interface, this holds for example for ontology editors as well as for the interfaces used for publish information items [14].

3.3 Information Access

The evaluation criteria for Information Access Layer are also important factors for SW portal as this layer is the front-end of SW portal for community user.

As a web-application, a SW portal should provide appropriate usability and availability to represent a user-friendly interface for a virtual community. In addition to this, a SW portal should provide advanced functionalities for community users with semantic capabilities [25]. Although there are already proposed elements of discourse to evaluate web usability [22], in this paper – with regard to the aim of this survey – we will concentrate on semantic features for information access of SW portals on the basis of general usability as web-application and the effectiveness of functionalities provided for community.

3.3.1 Usability

Usability addresses the relationship between a portal and its users. For a SW portal to be effective it must allow users to accomplish their tasks in the best way possible. Usability is the quality of a system that makes it easy to understand, easy to use, easy to remember, error tolerant, and subjectively pleasing. Usability depends on a number of factors including how well the functionality fits to user needs, how well the flow fits user tasks, and how well the response fits user expectations. A consistent look-and-feel makes it easier for users to recognize where they are and where they can go when navigating a large information space. However, portals are a special breed of web offering a blend of information, applications and services. Thus, a portal's usability is more than the usability and design of its parts. It has also to care of more general issues like packaging, structuring, integrating and organizing information and knowledge provided to their user community. Since a portal usually has a specific functional objective, users have certain expectations on what they can get and what they can do. In other words, the usability of portal depends on community-specific information and community-centric functionalities. Thus technologies are required to realize its usability to get maximum benefit from the semantic structures.

3.3.2 General Assessment as web technology

As a SW portal is a special breed of web application, it should satisfy basic requirements usually used for the assessment of web sites. A lot of scientific approaches have been developed for evaluation of web sites in the field of HCI [24] and many design guidelines have been proposed to build more effective web sites. Therein extensive practical issues for user interface design, usability, and user-centered development are mentioned [8]. For our evaluation purpose we consider the basic web functionalities such as navigability and readability to increase user satisfaction as well as layout and visual clarity.

Coverage

A SW portal should be able to provide relevant information completely to its user community. Relevance and Completeness of information offered in a SW portal will be its ultimate goal. Thus for evaluation of SW portals it is important to determine the depth and the level of coverage of information. Coverage means not only the scope of available information but also the effectiveness or uniqueness of a portal. The width of coverage is related to the scope of portal while the depth of coverage is related to semantic relevance of information resources. Broad coverage in depth and width will ensure user satisfaction. Semantically enhanced search and navigation can prove its merits when it covers abundant of information resources.

Maturity of Implementation

The maturity of implementation means the completeness from a technical point of view concerning the status of implementation of the functionalities in a SW portal. All functionalities accessible through user interface should properly operated without errors or broken links. Some SW portals provide good error messages in plain language to precisely indicate the problems and constructively suggest a solution. However, even better than a good error message is a complete

design which prevent a problem from occurring in the first place. The maturity of implementation is also a criterion to show the stage of realization in usage of Semantic Web technologies.

Personalization and Communication

One of main merits of community portals is that users can customize the portal's functionalities to their personal convenience. Personal information management by means of personal topic maps improves the effectiveness of the portal. Besides, this provides a means for user satisfaction. While personalization is for the single users, communication facilities (i.e. collaboration features) are for the virtual meeting room to share and exchange information among users. As a portal creates a virtual community, these facilities for communication among users help to achieve the goal of the portal. In SW portals, the semantic mark-up is especially helpful to facilitate information exchange embedded in the midst of the interaction between community users. Making communication channels available can make a portal become a real virtual community.

Reliability of Information Resources

The information provided in a SW portal should be semantically complete and consistent. A portal should provide the relevant information of the specific domain of the community and users should not have to deal with ambiguous vocabularies and actions that mean the same concepts. This aspect is related to the quality and credibility of the SW portals.

Help and Documents

Even thought it is better if the portal system can be used without documentation it may be necessary to provide help and documentation. The 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.

4 Evaluation of Semantic Web Portals

In our Evaluation, we have identified a number of Web portals that apply Semantic Web technologies to enhance their information sharing capabilities. A detailed evaluation has been accomplished for the SW portals most successfully using these technologies and most closely fitting our definition of a SW portal. We have inspected two academic portals (Esperonto and OntoWeb[7] portals) and two commercial portal technology infrastructures (Empolis K42 and Mondeca ITM). In this section, we will provide a comparison between these portals following the three layers of our evaluation scheme. Other portals have been also identified, such as mentioned in section 4.5. Nevertheless, these portals only make a partial use of Semantic Web technologies and, therefore, they are not included

[7] We have evaluated the technology of the main portal: http://www.ontoweb.org. However part of the OntoWeb Framework are also OntoWebEdu and OntoWeb RoadMap Portal mentioned in section 4.5.

in the detailed comparison, but evaluated with regard to their characteristic features, i.e. that which use semantic web technology.

4.1 Esperonto Portal

The Esperonto Portal is a case study of the ODESeW knowledge portal generator developed by the Ontology Group at Facultad de Informática, Universidad Politécnica de Madrid. It serves as the intra- and extranet platform for the EU project Esperonto.[8]

4.1.1 Grounding Technologies

Technology	Name, Release	Comment
Operating System	Windows 2000	Also Unix/Linux possible
Database	Oracle 8.1.7	Also tested with MySQL and available for any JDBC compatible DBMS
Document Repository	File system	
Web Server	Minerva Application Server + Tomcat	Migration to a different product is planned
Applied Ontology	Five different domain ontologies	
Ontology Language	WebODE Knowledge Model	OKBC compliant
Export / Import	XCARIN, F-Logic, RDF(S), OIL, DAML+OIL, OWL	WebODE feature
Inference Engine	OKBC based inference engine	Used during ontology construction
Ontology Editor	WebODE Ontology Editor, OntoDesigner, WAB	Others are possible due to the import feature
UI Technology	HTML, XML, JSP, Java applets	
Browser compatible	IE 5, Netscape 4,7 (or higher)	
Pricing / License	Free evaluation	
Product Website	http://webode.dia.fi.upm.es/sew/	
Demonstration Website	http://www.esperonto.net/	

Table 2: Grounding Technologies Esperonto Portal

The portal incorporates a classical 3 tier architecture. An Oracle database and the file system of the server as persistence layer; in the middle tier the Minerva Application Server is responsible for database connectivity and for providing access to the WebODE Ontology repository and for service management; the presentation layer is handled by a standard browser. Servlet execution is currently done by the Apache Tomcat web server.

System Technologies

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

Data Management. The documents are stored in the server file system. There is no indexing or sorting. A folder structure according to the ontology concepts is used. Therefore it uses no standard packages for the document management, focusing more on the ontology part. The database is connected via JDBC and the access to the ontology repository is realized via RMI[9] by using the WebODE API.

System Maintenance. For authentication and back up standard mechanisms of the Minerva Application Server are used.

Semantic Web Technologies

Ontologies. Ontology handling is completely done by the underlying WebODE platform which itself uses a relational database as backend.

For the Esperonto portal five different domain ontologies were developed, namely project, documentation, person, organization and meeting. These ontologies are describing R&D Projects, especially IST-Projects and are intended for reuse. The ontologies are connected through several relations. However, for the advanced search functionality only direct attributes within a single ontology are considered.

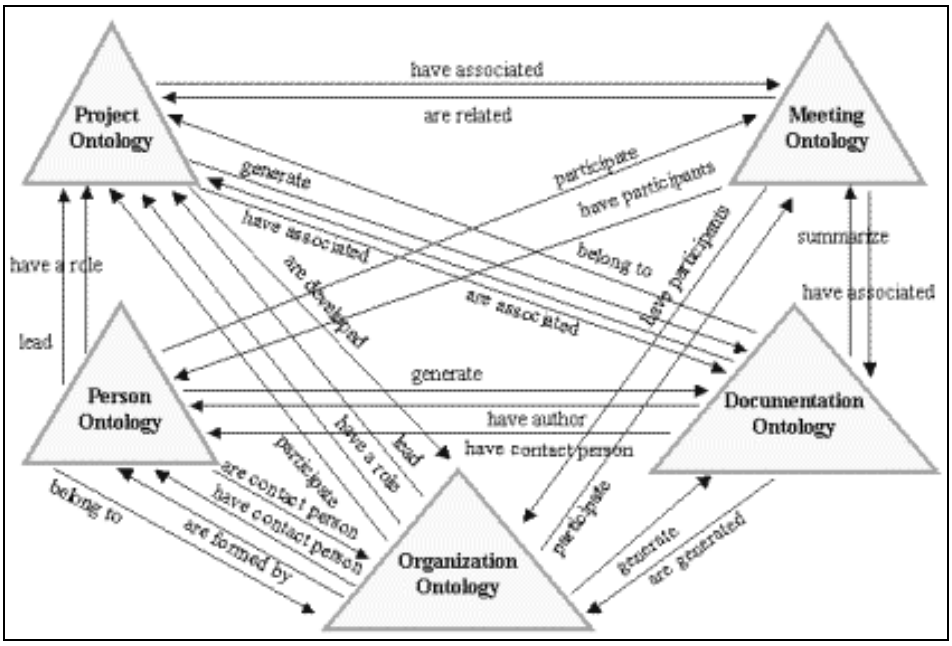

Figure 2: Domain ontologies used within the Esperonto Portal

The ontologies have a depth up to five levels, each of them between two and eight concepts width. They are developed straightforward and each of them covers its particular sub-domain appropriately. However, different document types are not explicitly modeled within the ontologies. Furthermore currently there are no multi-language capabilities.

Inference and Reasoning. WebODE provides an axiom editor (WAB) for modeling axioms to test consistency of the information in the portal. In the current version these axioms must be executed programmatically.

[9] Remote Method Invocation (a Java RPC mechanism)

Ontology Maintenance. All instances can be modified using the portal interface, although only administrators and registered members with appropriate permission can perform these modifications. In addition administrators and members with appropriate permissions can edit the ontology schema directly via the WebODE Ontology Editor. Furthermore a JavaApplet (Ontodesigner) can be used to change the ontology. Currently there is only one basic versioning feature: if a concept is removed from the ontology, its instances become instances of its superclass.

Import and export features are provided by WebODE. The possible formats are: XCARIN, F-logic, RDF(S), OIL, DAML+OIL and OWL.

Semantic Web Services

As explained before the Esperonto portal is powered by ODESeW [6] which relies on WebODE [5]. Ontologies in WebODE are supposed to be accessible remotely via Web Services technology around SOAP and WSDL. [5] states that WebODE services will soon be made available as Semantic Web Services. Nevertheless, in WebODE current version no web service is implemented. Further, no details are given about technologies to be employed in WebODE and no information has been found regarding this extension of the WebODE framework.

With regard to the extend of Web Service technology usage, the portal in its current state is neither it is using technologies nor using semantic extensions, thus not offering any programmatic access to the portal contents and functionalities via Web Services (only RMI access is available).

4.1.2 Information Processing

Creation

The creation of new information items in the Esperonto Portal is restricted to users with the appropriate permissions. The classification of portal users is explained below as it affects several steps of the information processing layer:

Administrators: apart from browsing and editing any information in the portal without restriction, administrators perform the following: user management, ontology selection for the portal, visualization management (e.g. attribute ordering for concepts and the information to be visualized for all the instances)

Guest user: the default user accessing the portal without any login process. The guest user can browse only the public information in the portal.

Members: registered users are grouped into different categories with different access/update permissions in the portal. In general they can browse, create and edit information items. This role is generally assigned to the people who are in charge of the portal information maintenance and contribution.

Only members with the appropriate permissions and administrators can create new information items, after a login step. To create a new item the user has to browse into the portal to select the desired type of information item (ontology concept) to be created. After that, a form (identical for any kind of concept) is available to introduce the name of the concept instance and its description. After introducing this information, it is sent and a new instance of the concept is created

and thus implicitly assigned to the ontology. Details of the information item are not given at this stage but via the editing functionality explained below. The instance name given during the creation process is used as the instance identification. As the user does not necessarily know all the instances names in the portal, this point can bring some difficulties in the creation process (e.g. if he tries to create two instances with the same description). Regarding the usability of creation support, the user may expect to provide all the information for the new item at this step and not to be forced to go through the editing process to complete the creation of the new information item.

Publication

After creating the new information item it is automatically published and made accessible for any portal user. Thus there is no explicit quality control of the information items created. It is assumed that users with creation rights (normally project members) will provide contents with the expected level of quality.

Organization

The created information items (ontology instances) are stored in the WebODE ontology repository explained above. As only the ontology name and description is given at the creation phase no documents have to be stored. Nevertheless, if documents are provided at the editing stage they are stored in the server file system. No indexing is performed on these documents.

Access

The Esperonto portal provides three access levels, detailed in the following.

The first level is a keyword based search performed over all the information items stored in the portal. It is accessible from any point of the portal and retrieves information items containing the search term in their name or description edited during creation. In addition it can be restricted to a concept selected by the user. Only one word can be given to the search furthermore, the search can be only restricted to one kind of information item, not allowing combinations of several types of concepts.

The second access level allows the user to browse the ontology and to retrieve all the instances for that concept and its subconcepts at every browsing step.

The third level of search is a more precise ontology-based search. In addition to the ontology browsing a search functionality for the visualized concept and its subconcepts is available. It allows the user to specify attribute values of a given concept to perform a search on. In our evaluation we found that this search does not work properly and no instances were retrieved for many of our searches.

Maintenance

As for the creation of new information items maintenance opportunities are related to the different user levels.

Similar to information item creation, only administrators and members with appropriate permissions can modify these. Modification support of instances only includes editing functionalities. Users with adequate permissions can edit the properties of an information item. Nevertheless, the instance name and

description cannot be updated. Deleting information items is not possible, and there are no indications in the portal about how to do it. In our evaluation we discovered that deletion of information items is restricted to portal administrators (supported by WebODE directly or ODESeW).

Ontology schemas can be modified by portal administrators and members with necessary permissions. Nevertheless, this cannot be done by using the portal interface, but only by using WebODE directly.

Collaboration Features

Within the Esperonto Portal there are currently no collaboration features, besides the possibility of editing the underlying ontologies. Neither mailing lists nor a chat or similar features are provided.

4.1.3 Information Acess

Usability

Portal members with the necessary permissions can use the portal to read and write all the concepts, instances and attributes if are given. These features provide the convenient test bed to construct ontologies more efficiently with members' cooperation. However, the use of the portal to create and maintain contents presents a low usability level. As stated above the creation stage is mixed with the edition step. To create a new information item the user has to follow a rather contra intuitive process. Regarding navigation, the separation of similar hierarchy structures is improper from the point of view of the web site design guidelines.

The portal contains all deliverables and technical documents useful for the project members and external visitors. However, it provides only project outcomes but does not include any referential materials that may be useful for research activities. Although the portal has some functionality to add this kind of materials, they are not being used. The announcements or news related to the project are also lacking in substance. Participation of community users is restricted and the communications among users are indirectly controlled through moderation by administrators, the portal does not offer the usability expected from project members. The Esperonto portal places, at this point, much emphasis on the dissemination of project outcomes and the construction of practical ontologies, but its usability can be improved.

General assessment as web technology

As users are mostly related to the project and their reasons to use the portal are obvious, the portal does not pay much attention to the user interface and other general enhanced web technologies. This is considered a weak point of the portal. It should offer a convenient user interface for guest users as one of the purposes of the portal is project dissemination.

The portal uses a hierarchical navigation structure based on ontologies with a simple frame side by side. This structure is a frame-based menu as used in many web sites. Basic websites design guidelines such as layout and visual clarity are not considered, and the portal also does not make any use of abundant web technologies. Although mainly users are project members it should give more

attention to human factors and apply improved web technologies. The search function is unexpectedly simple regarding that it is an ontology-based portal. The advanced search does not work properly. On the other hand, the portal provides a good environment as an ontology repository and the ontology construction is performed in an efficient manner.

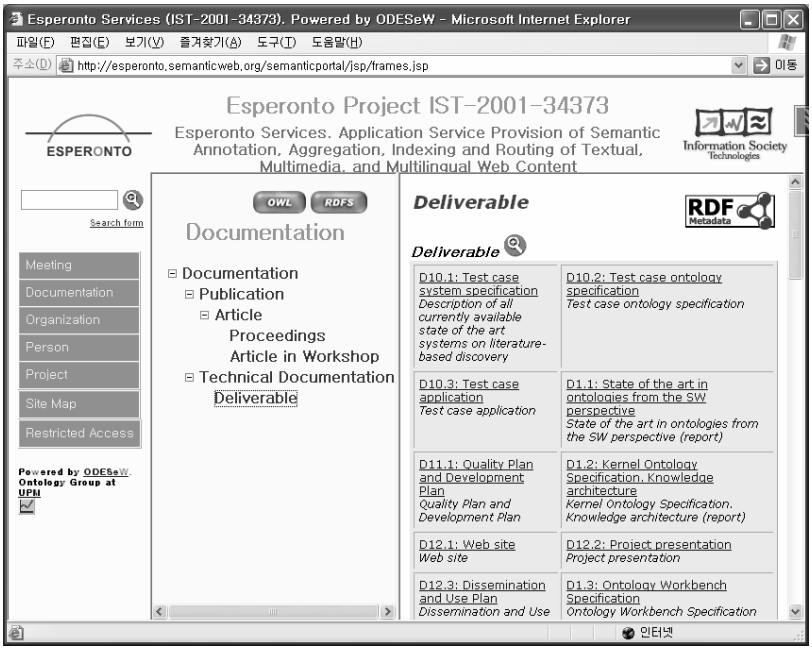

Figure 3: Screenshot of the Esperonto Portal

Coverage. At the moment the scope of the site is restricted to project-related information, confirming to the purpose of compiling and disseminating research results of the Esperonto project. The portal offers five ontologies that describe R&D projects, publications produced in this project and technical documentations such as deliverables (see above). As the Esperonto project aims to develop the core ontology technologies, all the information offered in this site is up-to-date and it constitutes an excellent reference to understand the state of the art on ontology research and its applications.

Maturity of Implementation. During evaluation of the portal we found several errors, for example while editing an information item or using the advanced search. So we perceived a not high enough maturity of the portal implementation. In addition, the site map of the portal is still under construction.

Personalization and Collaboration. The site does not provide personalization features. On the other hand, it provides a good collaboration environment to construct ontologies. Users who have full read and write permissions can indirectly share their ideas about the ontology design in terms of cooperative editing of ontologies. An advanced ontology versioning mechanism will be necessary to trace and control the updated concepts. However, the user community – especially the research community – is expected to have more features available in order to achieve an effective communication. The portal omits several essential functionalities to be a complete research community portal, such as an electronic bulletin board and mailing list archives.

Reliability of Information Resources. All resources are produced by community members according to the project schedule and fully reviewed by research members. The site is evaluated as one of the best sources of the latest ontology research.

Help and Documentation. The site contains only a brief description of project. The community users are supposed to know the goals and purposes of the site. Thus, there is no help or detailed usage explanation. Nevertheless, as using the portal becomes sometimes difficult, more documentation should be available, especially for guest users in order to facilitate and encourage its use.

4.1.4 Summary

The evaluation has pointed out some strengths as well as some weaknesses of the Esperonto portal.

The strong points are mainly related to the ontology management facilities relying on WebODE which presents a reasonably elaborated framework to support the construction of a semantic portal. The information contained and its reliability makes the Esperonto portal one of the best sources on ontology research.

However, some of shortcomings have been found especially concerning information processing access functionalities. Mixing creation and editing function and not allowing the deletion of information items make some of the information life-cycle steps incomplete and difficult to follow. In the information access layer we found a not mature enough implementation of the portal, lack of collaboration features, a limited use of common Web technologies, an insufficient help and documentation, and especially an improvable level of usability. All these aspects require important changes to make the Esperonto portal a satisfactory SW portal and to better show the improvements that can be achieved by using Semantic Web technologies for Web portals.

This Esperonto portal is an instantiation of ODESeW capabilities in the domain of research projects. The evaluation of ODESeW is independently of the concrete instantiation presents it as a fast way to build SW portals once the appropriate ontologies have been defined in WebODE, which makes it a promising technology in the area.

4.2 OntoWeb

The OntoWeb Portal [10] is a community portal for academic to industrial partners who share an interest in the Semantic Web. It was set up as part of the EU project OntoWeb (IST-2000-29243). It is built up on the ZOPE Application Server and a Content Management Framework (CMF) offered by the ZOPE Cooperation. [11]

4.2.1 Grounding Technologies

[10] Webpage: www.ontoweb.org
[11] cmf.zope.org

Technology	Name, Release	Comment
Operating System	Linux	
Database	ZOPE Object Data Base	
Document Repository	ZEO Server (part of ZOPE)	http://www.zope.org/Products/ZEO
Web Server	ZOPE Application Server 2.6.1	http://www.zope.org
Applied Ontology	Domain Ontology + Portal Ontology (e.g. object types)	
Ontology Language	RDF(S) + extensions	
Export / Import	RDF(S)	
Inference Engine	-	
Ontology Editor	Outside of portal, portal admini-strators can modify the onto-logy (schema & instance data)	
User Interface Technology	CMF (part of ZOPE), Java Servlets	
Browser compatible	- IE 6.0 + - Netscape 4.7 and higher - Mozilla	
Pricing / License	Open source	

Table 3: Grounding Technologies OntoWeb Portal

The portal is build up on the ZOPE framework which provides basic content management functionalities. It uses a 3-tier-architecture. Persistent storage of documents is completely handled by the ZOPE Application Server and the CMF. Everything connects to the same central storage instance. For the presentation templates are used from which an HTML / JavaScript or an RDF presentation can be generated.

System Technologies

The storage device is the Zope Object Database (ZODB), an object-database included in ZOPE. ZOPE additionally offers ZEO (Zope Enterprise Objects), a remote server for storing information used by distributed applications in a central server. This allows reuse of information items in different SW portals using the OntoWeb Portal technology. ZOPE handles the standard internet protocols – HTTP, FTP, mail protocols. All storing and indexing is handled by ZEO, portal containers and the CMF.

Ontologies

The OntoWeb ontology represents an application ontology: that means it provides all ontological aspects that are needed to provide the terminology in order to run the portal. This covers all content types of the portal (e.g. Document, Image, Project, etc). Parts of the DC Metadata Ontology[12] are imported used for basic

[12] see: http://dublincore.org/documents/dces/

information item description. A BibTex ontology allows Bibliographic references exchange. The depth of the ontology is maximal 3 to 4 levels.

Logic and Inference Method. Currently OntoWeb uses just RDF(S) to structure its content. For the future it is planed to extend this with features of OWL, e.g. symmetric properties.

Ontology Management. Content Types (i.e. ontology instances) are maintained within the portal, thus changes are made in the ontology and ZOPE Repository once at time. Ontology Management concerning the schema level are performed outside the portal.

4.2.2 Information Processing

The following analyses the information processing features of the OntoWeb portal according to the criteria defined in the evaluation criteria catalogue (section 3.2).

Creation

The creation phase of the information item life cycle in SW portals is concerned with tool support for creating new information items. The OntoWeb portal differentiates between several types of information items defined as the top level concepts of the OntoWeb ontology. For each of these the portal offers form-based editing support wherein the user edits information for a new information item he wants to submit into the portal.

The information editable by the user are divided into three areas: First so called ´Base Data´ which are displayed as a short description in the portal, second values for the properties of the appending concept of the OntoWeb ontology (including uploading document if a document-type information item is created), and third so-called ´metadata´ which allow to specify how information processing features of the OntoWeb portal shall handle the new item. This creation support is form-based relying on the OntoWeb ontology and thus allows ontology-based information item publication and management (see below).

Publication

The publication of a new information item to the portal community is performed by a publication workflow which is based on the user rights: A “normal” user can only add instance data while the ontology schema can only be changed by the portal administrators. There are two possible publication states for an information item, namely:

- Private: They can be viewed only by its owner and portal managers.
- Published: It can be accessed by any portal visitor once its publication is approved by one of the site’s reviewers. In addition, an information item can have an effective and expiration date, that state the period of time for which the item will be accessible. Only one of these dates can be given, thus stating only from which date the item is accessible, or stating until which date it will be valid (in this case, it will be accessible from the moment it is published).

For publishing a newly created information item in the portal, the user submits the descriptive information edited via the “Submit”-button in the state-form of his personal folder. As soon as the new item is submitted for publication or published in the portal, its state can be changed by the owner but it is not editable anymore. The new item is reviewed by the portal reviewers, who decide whether the item proposed by the user is suitable for the OntoWeb portal or not. By this, the quality of information on the portal is maintained. Administrative permissions can be given to a user to let them decide about the publication state of portal items.

To facilitate publishing of documents in the portal, existing BibTex information can be imported as instances of the OntoWeb ontology publication concept.

Organization

The organizational principle of information items is the OntoWeb ontology. Out of the ontology-based description forms a newly published information item is automatically assigned as an instance to the ontology concept it has been created for.

Since all data management issues are handled by ZOPE the information items are stored using this system. Indexing for increasing search performance is done for the information item descriptions, whereas all other objects of an information item (e.g. documents) are ‘only’ stored without indexing.

Access

The OntoWeb portal provides several ways to access information. There are two navigation menus: one on the top pointing to the top-level functionalities of the portal and a tree-structure menu on the left which is an automatically generated navigation box of all accessible folders on the current folder level. Further, information boxes are located in both border areas that point to recent entries of certain information item types of the ontology. These are namely: important links (featured content), news, and upcoming events.

Currently the OntoWeb portal provides two separated search facilities: one is reachable through the “search”-button on the top navigation bar, and the other through the “browse ontology”-button. The former is provided by the AIFB, while the latter by the VUB Star Lab.

The VUB-search is designed as searching by browsing the OntoWeb-ontology. It starts with the ontological taxonomy presented on the left hand and retrieves all instances of the current concept. The user can perform further searches according to the properties and the relations of the current concept to retrieve narrowed down search results. In our classification, this is an ontology browsing search.

The AIFB-search uses the extended OntoWeb Ontology described above. The user selects ontology-concepts he wants to search information in and provides the search term and he also can specify further search filters. The search operation is implemented as a combined keyword and ontology-based search: If there is no information item found as instance of the selected ontology concept, the search automatically becomes a full text search over the descriptions of all information items (note that this is not a full text search over documents stored in the portal

but only on the descriptive information edited during the creation, resp. publication phase).

In the current implementation there is still a big gap between those two search functionalities, since due to technical differences both searches are not operating on the same underlying data, e.g. within the ontology based search of VUB a deliverable will not be found which is present in the ZOPE repository maintained by Karlsruhe.

Maintenance

The maintenance options for every information items are accessible through the information item presentation box. The users' rights determine the authorization for maintenance of information items: administrators can publish, reject, retract, delete, and change all information items, while each user can maintain his own information items in his personal folder.

As soon as an information item has been submitted for publishing or has been published in the portal, its owner can only rename an item, change its status or delete it; but it is not possible to change the descriptive information of an information item (only by changing the publication status). The storage devices do not provide versioning opportunities for information items: changes are overridden (they can be rolled back via a history function by the administrator).

Community Features

There are no explicit collaboration features offered in the OntoWeb portal. The descriptions of portal members can include personal descriptions, homepages and links to the organization. The Ontology based search offered by VUB can be used as an expert finder, however the poor content and the missing integration to the rest of the portal make this feature unusable. An email list is maintained by the OntoWeb site and is currently the most used collaboration feature.

4.2.3 Information Access

Usability

The portal is intended as a place for information exchange, to reference resources, announce new events and disseminate research deliverables. The participation of many academic research and industrial institutes from countries all over the world raises the usability of the portal. However, the portal is a repository focused on the project and depends on the contribution of users for other resources which causes a lowing of its usability. The portal has to consider the fact that community users are world-wide and they have diverse expectations for using the portal which might be complied by functionalities for direct communication among users which need to be improved, in that sense the portal lacks community awareness, since its structure is not intuitive to all users, e.g. when browsing deliverables, they are organized according to different project phases instead of topics, authors or or organizations. The portal contains very useful additional functionalities for its users such as calendar service and ´Related Links´. These show how we can improve the usability of portal by using ontology technology.

General Assessment as Web Technology

The portal employs a neat menu bar and table structure, but visual effects are simple compared to conventional web sites. The dispersion of similar navigation functionality between the menu bar on the top of page and the navigation of the left of page are confusing because this may lose the consistency that is required in web page design and usage. On the other hand, the portal always tries to keep its original structure, i.e. the site maintains the same structure in the left and right of pages (only the Event and Portal Member section have different structures). The table elements in the left and right of the page do not also have their distinct features and are too narrow to display the content. Sometimes the user has to scroll a longer page, especially in ´Related Links´: this functionality is very useful and unique feature of this site. The implementation of functionality based on semantic relations among resources still needs to be improved.

Coverage. The site provides deliverables of the project and general references on ontologies. While the site aims to organize ontology thematic network, it has to reinforce its coverage to deal with abundant general references in addition to deliverables. When searching its knowledge base a few publications and references are retrieved. At the moment, the user cannot estimate how large its knowledge base and what they will get through retrieval.

Maturity of Implementation. The OntoWeb portal contains the core functionalities of a community portal. Nearly all functionalities are implemented fully and stable. The functional features for communication among users are a little of insufficiency. The portal provides indirect communication through a personalized folder. Though it seems that users do not get accustomed to a personalized folder, this will provide good alternatives for person-to-person communication. First above all, the portal applies ontology technologies to overall site design. This approach will be expected to enhance the usability as a SW portal. However, application techniques should be polished to use the innate capability of ontologies.

Personalization. The personalized folder in OntoWeb differs from the ones in other portals. This unique feature gives many merits to users although this feature is not actively used at the moment. The personalization is still unacquainted with users and the community users want to receive beneficiaries from the portal rather than contribution to community. Such a passive participation brings about less cooperation and makes the portal to be a web site supplying referential materials.

Reliability of Information Resources. The completeness of the project publications and the publication quality control make the information resources reliable and meaningful. The referential materials and deliverables are recognized as the state of the art of ontology researches and used as basic references.

Help and Documentation. The site provides popup-style help messages. These are very useful because it offers just-in-time help messages. All documents introducing the portal are well written. However, the function of help menu is somewhat awkward since it open another window similar to main portal page without detail help.

4.2.4 Summary

The OntoWeb portal seems to be very well designed to fulfill its purpose as an information exchange platform for the Semantic Web research community. There are some minor dubieties concerning the grounding technologies – especially the usage of the ZOPE framework for data storage and management instead of a solution build exquisitely for ontology data management. The Ontology seems to be mature with regard to the information necessary to semantically annotate the content types of the portal. The overall look and feel of the portal from the users' perspective is professional. As a closing aspect it is to mention that there are plans to employ the OntoWeb portal technology for other SW portals [16]. Plans for integrating Semantic Web Services into the portal are mentioned by the developers, although these plans are not concrete and their viability and extension cannot be evaluated at the moment.

4.3 Empolis K42

K42 is a knowledge management product developed by Empolis based on the Topic Map paradigm. It offers a basic infrastructure for storage, querying and maintenance whereupon portals can be build by application developers. During our evaluation, the product portfolio within Empolis was changed: the K42 development as stand alone product is not continued but its functionality will be integrated in the e:kms knowledge suite.

4.3.1 Grounding Technologies

Technology	Name, Release	Comment
Operating System	Linux/Unix, Windows NT	
Database	K42 Server with own persistence mechanism	Optionally a relational database can be deployed
Document Repository	n/a	
Web Server	TomCat v4.1.24	
Applied Ontology	TopicMap of XML Europe Conference	
Ontology Language	Topic Maps	In addition to the standard association templates are sup
Export / Import	XTM	
Inference Engine	-	
Ontology Editor	WebAuthor	In addition any tool for creation of TopicMaps (XTM-files) can be used
Userinterface Technology	HTML, Javascript, Java Applet	
Broswer compatible	Intenert Explorer 5.5 SP2 or higher	For WebAuthor, TMV and Ontogen
Pricing / License	Free evolution	product as stand-alone version is not longer available (now part of k:ms)

Demonstartion Site:	http://62.231.133.220/xmlus02-nav/index.html
Product information	http://k42.empolis.co.uk/

Table 4: Grounding Technologies of Empolis K42

System Technologies

The central part of the platform is the k42 Server which is able to store and query topic maps. Besides, the standard distribution includes the following tools: WebAuthor, TopicMapView (TMV for short) and Ontogen. The latter is an end user tool to visualize Topic Maps, the 2 former are more administration tools for Topic Maps. All three are implemented as Java applications and by default deployed in the TomCat Server. These tools can be seen as part of the middle tier which has to be extended for a complete portal application. In the following we refer to the concrete implementation within the XML Europe Demonstrator.

Data Management. The K42 Server is a Topic Map Server written in Java. It stores the K42 Topic Map model in a native format directly to the file system or use a database as backend system. It can be accessed via a Java API or through TMQL[13] a Query Language for Topic Maps, which is currently in progress to being standardized. The transfer itself is done using socket connections and passing serialized Java objects back and forth. Each connected component (like WebAuthor) needs a communication plug in on the Server side, that listens to a specific port.

System Maintenance. With the TMV application it is possible to backup and restore the data model as XTM files. Furthermore there are command line tools and functions in the Java API available to automate this process when needed.

Semantic Web Technologies

Ontologies. TopicMaps are standardized as ISO/IEC-Standard 13250. [21] shows how they can be converted into RDF and vice versa. Hence you can also regard XTM – the XML representation of this standard – as a language for representing ontologies. The K42 Server is completly compatible with ISO/IEC standard. In addition so called association templates are introduced which roughly are comparable to the rdf:subClassesOf property. Association templates enable the instantiation of associations.

Figure 4 shows the Employment template.

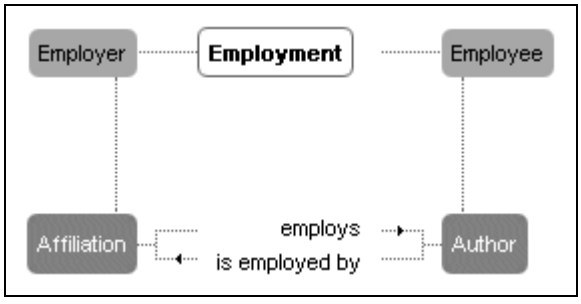

Figure 4: Visualization of Employment Association[14]

[13] Topic Map Query Language: http://www.isotopicmaps.org/tmql/
[14] http://62.231.133.220/xmlus02-nav/xtm/employment.html

For linking conceptual knowledge into the Topic Map schema to real world instance URI are used. The Topic Map employed in the XML Europe portal has nine main topics each with around 100 sub topics. Nine different association templates interconnect the topics.

Inference and Reasoning. Since K42 uses Topic Maps no explicit inference techniques used. But the arc construct of the topic map standard can be used in the same way then an inverse or symmetric property. In this sense inference is supported.

Ontology Maintenance. As introduced earlier, K42 provides 3 applications for maintaining ontologies. WebAuthor enables modifying all aspects of Topic Maps (topics, roles, arcs, etc.). It can be used as a tool to administer a running portal through a web application. Within ontology terminology this can be seen as Ontology Editor.

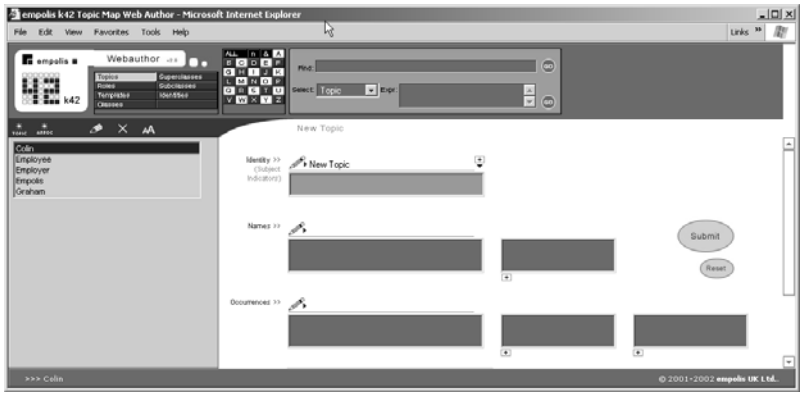

Figure 5: Screenshot of WebAuthor

Ontogen provides a standardized way for visualizing Topic Maps to the end-user. The only modification allowed in this tool is adding instances. The Java API can also be used to create instances via programmatically creation.

The current release neither provides functionalities for ontology versioning nor collaboration support for concurrent modifications.

Semantic Web Services. K42 does not offer any sort web service interface by default.

4.3.2 Information Processing

The default tools shipped with this portal infrastructure allow users only to access existing information items while the creation, publication and maintenance is left to the portal administrator with support of special tools. This approach is different from the SW portals evaluated in the previous sections: all information items are provided and maintained centrally by the portal administrator while the users are only “information consumers”.

The following evaluation relies on a demonstration toolkit for application developers available from Empolis and the demonstrator for the XML Europe 2002 conference.

Creation

The creation of information items can only be carried out by the administrator, wherefore the before mentioned tools exist: “WebAuthor” allows web-form based editing of Topic Maps. Ontogen allows creation of occurrences (i.e. instances) according to the defined model. By default, the system provides no support for uploading associated files during the creation of the according instance.

Topic Map occurrences – the information items accessible by users – are restricted to textual descriptions for attributes (e.g. name, email address of an author and a short description of the document described) as predefined in the corresponding Topic Map, and hyperlinks to internet resources.

Publication

As well as the creation of information items the publication can only be performed by the portal administrator. The border between the creation and the publication phase is intangible because all information items are published by the time when they are submitted to the system via the creation opportunities described above.

Organisation

The storing and indexing tasks for Topic Maps and Topic Map Instance data are handled by the K42 server. The underlying conceptual model is the K42 Topic Map model which defines the modeling primitives for Topic Maps in the sense of a representation ontology similar to RDF Schema.

Access

There are two possibilities for information access by users. The first one is a browsing feature of the Topic Map and its instances which can be considered as an ontology-browsing search in our evaluation schema. This can be done via an interactive applet (Start Tree) that displays a hyperbolic tree, or a standard layout with HTML tables (Meta Index). The second information access feature is a search on the descriptions of all information items.

Maintenance

The maintenance task of all information items in a K42-based portal is left to the administrator. The same tools mentioned above for creation can aid on different tasks, e.g. deleting an occurrence. The Framework by default does not provide any further support for data management in a K42-based system.

Community Features

There are no community features provided in the basic K42-system.

4.3.3 Information Access

The evaluation of the Information Access layer refers to the XML Europe 2000 portal based on K42-technology.

Usability

The XML Europe site is a portal for specific conference and expositions. With regard to this aim, the portal neglects some important information such as special events, detail session schedule and information, transportation and help desk.

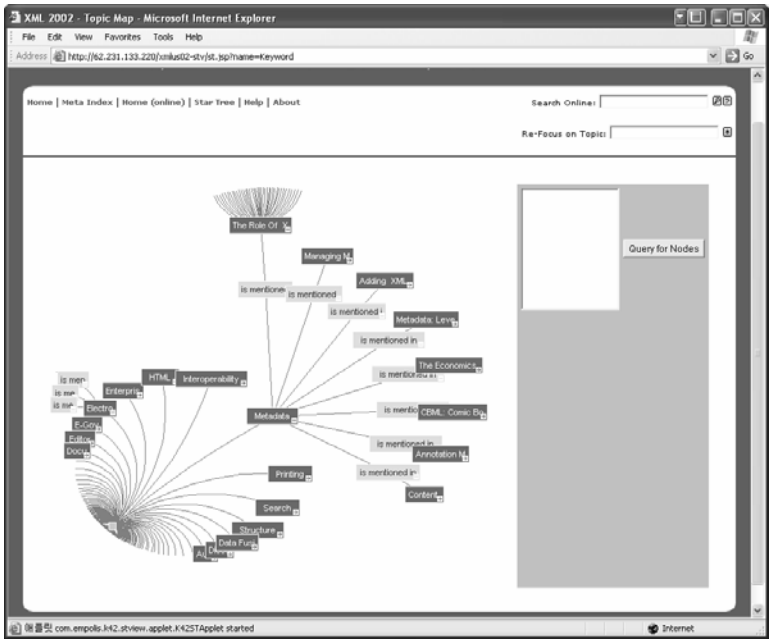

Figure 6: Screenshot of the StarView Applet (K42)

General assessment as web technology

The overall structure of web site is focused on navigation over its index. So the site does not consider using other web technologies. It has a very simple layout without frames, tables and graphics.

Coverage. All offered referential resources are online conference proceedings. It provides presentation materials and information about authors. Although it is a conference and exposition portal no information on vendors and products are offered.

Maturity of Implementation. The site as a conference portal misses many important functionalities. The site only shows how semantic metadata can be used for site navigation rather than implementation of portal site. The site deploys the basic functionalities that the K42-system provides for a portal site.

Personalization and Collaboration. Even though important for conference portal, this portal does not provide any means or channels to communicate each other.

Reliability of Information Resources. The papers and articles in the on-line proceedings are written by the experienced expert in its area. Some of them are only abstract or short articles difficult to understand what they want to present.

Help and Documentation. The site has detail help page for the explanation of navigation and search functionalities since they are the main features of the site. No other documents about conference and exposition are presented except the brief introduction to Topic Maps.

4.3.4 Summary

K42 is a commercial product leveraging advantages of explicit conceptualization of knowledge. Instead of classical ontology languages Topic Maps are used. Its

focus is to provide an easy to use and scalable repository to structure information. The tools shipped along with this might help to build a portal. These tools only support handling semantically described data but there is no support or framework for user interface or interaction technology. Thus the Empolis K42-system can not be rated as a SW portal development tool suite, but only as an infrastructure solution for Tpoic Map data management.

4.4 Mondeca ITM

Mondeca is a software provider targeting at knowledge management and document organization markets. ITM is a software tool and a development platform based on semantic technologies, ontologies, and linguistic tools. It is a tool for knowledge based management and knowledge automatic acquisition, designed for content organization and federation. As running example we have used the Semantopic[15] home page, which was build with ITM version 1.4. We also have used a demo of a portal for tourist resources provided by Mondeca.

4.4.1 Grounding Technologies

Technology	Name, Release	Comment
Operating System	Unix, Linux, Windows	
Database	Oracle 8i, 9i, PostGreSQL 7.2	knowledge representation storage
Document Repository	Any content management or file system	
Web Server	BEA Web Logic, IBM Websphere, IPlanet, JBoss	Actually used :BEA WebLogic, IBM Websphere
Applied Ontology	Any client ontology compliant to DAML/OIL/OWL specification	ITM support any semantic relationship between topics (Topic Maps as basis)
Ontology Language	Own model based on Topic Map and OWL (extendable). RDF also used	
Export / Import	OWL, XTM structured files	Only import. External ontology creation in OWL before import to ITM
Inference Engine	-	Plans for integration of open-source OWL compliant inference engine
Ontology Editor	ITM-Editor, Protégé (external)	Protégé for initial ontology creation, updatable directly in

[15] http://mondeca-publishing.com/publications/semantopic/anonymous/title10303.html

		ITM
Userinterface Technology	HTML/Javascript	
Broswer compatible	IE 5/6, Netscape, Mozilla	
Pricing / License		
Demonstartion Site:	http://mondeca-publishing.com/publications/semantopic/ anonymous/title10055.html	
Product information	http://www.mondeca.com/english/	

Table 5: Grounding Technologies of Mondeca

System Technologies

The system's core is a J2EE application component that manages the metadata repository and maps its internal structure to a relational database. Different documents repositories can be used (file system, other content Management System), but a special adapter has to be written for each different one. For the presentation layer ITM employs a standard HTML solution for editing, navigating and querying based on its internal API and JSP technology.

Data Management. As stated above, ITM has its own self developed component for managing the knowledge repository. It can only be accessed via a Java API[16]. The management of the actual data is not part of the core system. Special developed adaptors can connect to different types of CMS, for example a file system. The data transfer between the data base and the knowledge repository is done via JDBC for document data or a protocol dependent on the customer's connector, respectively.

System Maintenance. The possibilities for direct maintenance are dependent on the actual components used (e.g. which Application Server) and therefore is determined by the specific product chosen (e.g. BEA WebLogic administration console).

Semantic Web Technologies

Ontologies. As already stated in the K42 evaluation, Topic Maps can be seen as a representation technique for ontologies. ITM is compatible with the ISO/IEC standard. Extensions include association templates and constraints like time frame model and scopes. A scope, for example, can be used for managing user permissions on any object. In addition ITM uses an ontology described in OWL to describe the managed data.

Logic and Inference Method. As based on an OWL ontology the knowledge representation can be used as a base for inference. At this point of time ITM does not include any inference engine. However, there is a plan to integrate an open source inference engine in a future version.

Ontology Maintenance. In an initial stage the knowledge model can be created as an OWL file, e.g. with a 3rd party tool like Protégé2000. After the ontology is loaded it can be edited with the ITM Editor, a generic tool for Knowledge Base Management. The initial development is done using a different tool because the ITM Editor is not as powerful as existing tools like Protégé. Addition of instance

[16] http://www.mondeca.com/doc_mondeca/en/help_APIs/pageGlobale_index.html

data can be done in several ways: it can be added by the end user (web forms), automatically by linguistic tools, or by parsing existing metadata (e.g. metatags in a HTML document).

The knowledge base can be initially populated by importing OWL files. As export format, XTM is available.

Semantic Web Services

ITM does not provide support for SWS at the moment. However, most of its API functions deliver their output in XML format (e.g. the query API), also SOAP is supported. With existing tools, the API functions could be migrated to Web Service technology, although this has not been done at the current version.

So neither Web Services nor Semantic Web Services support is provided. There are some (not detailed) plans to provide a set of Web Services in the context of an ongoing project which will build an ASP service using ITM.

4.4.2 Information Processing

The information processing evaluation is based on a demo of a system for tourist resources access which uses the same ontology for several regions in Europe and includes multi-lingual support. It is important to notice that this demo is only a specific application of the underlying technology, used to evaluate the different steps in the information processing task.

Creation

New information items can only be created by users with the adequate permission. When a new user is created, a workspace is assigned to him – i.e. a definition of the part of the ontology with which he can work – together with the rights for this workspace.

The creation process is done through a form. Therein the user selects the kind of concept he wants to create, and then provides the necessary information to create an instance for this concept. Thus the information item is implicitly assigned to the ontology in this step. It can be assigned to one or more keywords in a defined thesaurus in addition to the ontology assignment. The information required to create the item is dependent on the ontology concept selected by the user.

Different kinds of relations to other items can be established during the creation process, completing with this information the creation of the new item. This follows a quite intuitive and easy process for the user.

Publication

The user can choose between two publication states for a newly created information item: ´proposal´ or ´validated´ (the latter means that the item is published and accessible for the users of the portal). Only users with appropriate rights can define an information item as validated. The proposal state means that the information item is not published yet, and needs to be validated to make it publicly accessible. A validity date can be stated for a new information item to determine the period when the item shall be in the portal.

The solution presents a limitation at this point: when the item is created and set as a proposal, no notification is sent to the potential validators. So if a user without validation rights creates a new item he has to wait until a validator notices that there is a new item waiting for validation.

Organization

A created item (if validated or not) is stored in the semantic knowledge storage system. The content management system used to store the documents attached to information items can be chosen separately as it is not imposed by ITM. So the actual storage and other data management issues are not fixed. The evaluated demo does not include indexing capabilities (apart from the indexing done by the ontology and the thesaurus). Nevertheless, there exists a built ITM application using Documentum[17]: Therein Documentum indexing relies on the ITM ontology and thesaurus.

A user can upload documents in two different ways: First, he can add a document as part of an information item. Second, the user can create a new information item, index it and add other concept specific information. Then, a relationship is established between the former information item and the new information item created for the document.

Access

Several means are available to access the contents of a portal based on Mondeca ITM. All means use the preferences defined by the user in his profile, including multi-lingual capabilities and date-based filter.

First, the user can browse the ontology, retrieving all the instances for the concept selected. In addition the user can navigate through the relations defined between these information items. Second, a keyword search can be used (full search whereby items either contain the keyword at the beginning or the search term occurs exactly in the item).This search can be performed over individuals, over universals (including keywords from the thesaurus associated to the item), or over documents (indexed using keywords from the thesaurus). Thirdly a semantic enabled search is provided. Therein the user specifies a keyword that the searched item must contain: further, the user can specify to which concept the item pertains (one or several possible concepts) and to what other information item it is associated. Additionally the user can specify which item attributes will be returned in the result of the search. This semantic search capability is quite useful to retrieve specific information items, but lacks the possibility of including specific attributes of the type of concept being searched.

There is also a plan to integrate graphical tools for navigation and editing. At the moment there is a Java Applet (TouchGraph[18]) for navigating through different concepts and instances are available. It is planned to be improved, as it appears too crowded at the moment and therefore its visualization is difficult. There are also plans to incorporate editing functionalities.

Maintenance

[17] http://www.documentum.com/
[18] http://www.touchgraph.com/

For maintenance of knowledge base content editing functionalities are available for the users with the appropriate permissions. Automated deletion of items is enabled by the associated validity date; physical deletions are possible though the user interface. Physical deletions also eliminate the semantic associations of the item in order to keep the coherence of the knowledge base.

The editing process consists of two steps: in the first one all the values defined for an item can be changes. In the second step semantic associations can be changed. This two-step process is quite intuitive and easy to follow for the user. But there is no specific interface to edit the ontology, thus making this process difficult. Therefore external tools have to be used, e.g. Protégé-2000. As a consequence no versioning mechanism is provided which limits the maintenance opportunities for the ontology.

4.4.3 Information Access

Usability

This system aims to provide a knowledge management solution for enterprise content organization based on Topic Maps. By several semantic web and ontology technologies used to organize, integrate and navigate content documents can be linked and grouped in a logical and relevant manner. This system has high-quality functionalities to manage ontologies, to index content and organize it. This provides users with an intuitive way for searching and browsing information resources. A notable function concerning its usability is the employment of textual and graphical navigation techniques. Although its primary target is content organization, it does not provide collaboration features necessary to be a full portal system.

General assessment as Web technology

The look-and-feel of the ITM user interface is clear. The tab interface used with table structure is efficient to categorize retrieved information items and provides intuitive views for navigation. The proper use of hierarchical representation of the used ontology structure also increases user navigability. The system offers diverse visualization techniques, including hyperbolic and hierarchical view on the knowledge space.

Coverage. The demonstration portal evaluated here offers information 6 categories (tools, standards, organizations, people, events, and project) but there are only a few information items available. Rating the general approach, this portal aims at providing all information concerned with an organization. It is getting too complex if there would be more items in the knowledge base.

Maturity of implementation. ITM fully implements its functionalities, integrated with standard components. It supports a usable development environment by employing standard components and technologies. However, the mixture of several similar technologies such as Topic Map, RDF and OWL might make system development too complex.

Personalization and communication. This system provides personalized content access with audit control, but users can not define their own customized virtual information space. There are portal functionalities required for collaboration and

communication among users. In a distributed enterprise environment users need their own work space and common shared areas for cooperation.

Reliability of information resources. The information sources are semantically complete as the rely on an ontology and consistent as there is a publication quality control. The development of the underlying ontology seems to be very complex since a lot of aspects have to be taken into account. (concepts, enrichment with enterprise terminology, many parties involved). This may result in semantic inconsistency in ontologies. There are no obvious means by which the end users can participate in developing and updating enterprise ontologies. The system needs to verify consistency between the imported ontologies and enterprise terminologies.

Help and documentation. Although the demo site is easy to use and self-explanatory, there is no help functionality provided. Only a link to the Mondeca homepage might be seen as documentation. It is to note that the portal evaluated has only been built for demonstration purpose.

4.4.4 Summary

ITM presents a well designed and flexible architecture which allows various implementations of SW portals using a common underlying technology.

The use of Semantic Web technologies is appropriately exploited, providing enhanced capabilities with respect to common web portals, such as improved information creation, maintenance and access. Its information items lifecycle is intuitive for the user at every phase, presenting a good use of the ontology designed for the concrete ITM-based portal. The ontology concepts are very well integrated in to the creation, maintenance and access steps, guiding and supporting the user in these tasks. The usability and general assessment of the ITM portal evaluated is remarkable.

Nevertheless, some problems have been identified during the evaluation. The semantic search can be improved by including specific information for the concepts being search, and the creation and editing of the ontology cannot be done cooperatively and is mainly based on external tools. In addition, the mixture of several similar technologies such as Topic Map, RDF and OWL makes system development complicated. The portal also lacks community features to support and improve communication between community members.

4.5 Other Portals

During our research we encountered some additional portals, that in some cases had not the necessary complexity or maturity to legitimate a full evaluation, but some aspects are worthwhile being mentioned. Remark that we do not claim to provide a complete list of all SW portals.

4.5.1 SWWS Portal[19]

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

This portal is developed by iSOCO[20] and serves as a dissemination platform for the EU-funded research project SWWS. It uses a domain ontology storing information about project partners, project members, the work plan with all the work-packages and all deliverables produced within the project. This ontology is created using Protégé2000[21] by the portal administrator. The ontology language used is RDF. Instances are also created using this tool and both the ontology and the instances are stored in files (there is no database support) and can be exported to the different ontology languages supported as by Protégé2000.

One interesting point of this portal is that, in addition to the domain ontology, it uses a visualization ontology (also created with Protégé2000). This ontology is a publication schema which allows organizing concepts and attributes that are to be published in the portal. This ontology does not duplicate the content of the domain ontology but links the content to publication entities using an ontology query language which enables visualization of the domain ontology in different views. A Java program is used to produce the HTML front-end. The portal does not include any facility to manipulate information items or the ontologies used. Users can not publish new content using the portal (the only way to do so is sending content via e-mail to the administrator who then creates an appropriate instance for this new item).

In Summary, this portal sticks to a simple and straight forward use of ontologies to structure information. It is a handy tool for ontology experienced webmaster, but its simplicity is also its drawback: the only semantic feature visible to the public is the query engine, which enables semantic search. For this reason, a full evaluation of the portal was not included in our survey.

4.5.2 Mindswap[22]

The owners of this site claim it to be the first site using the semantic web and to be powered by OWL-compliant technologies. This site tries to demonstrate how ontology technology can improve the functionalities of web site. However, the user can find only some embedded RDF documents. The site does not show the technological potential of ontology for improving web portal functionality as it does not apply Semantic Web technologies in any way: for example, not even the search box or menu is adapting semantic techniques. The information resources this site provides are already well-known and meager in quality and quantity.

In summary it is to state that this site is far from achieving its original intension as a Semantic Web enabled Web Site.

4.5.3 Karlsruhe Portals

The AIFB[23] at the University of Karlsruhe has build one of the first semantic web portal known to us. It was intended to be a platform for information exchange and collaboration for the “Knowledge Annotation Initiative of the Knowledge

[20] http://iSOCO.com
[21] http://protege.stanford.edu
[22] http://owl.mindswap.org/
[23] Institut für Angewandte Informatik und Formale Beschreibungsverfahren

Acquisition community" (KA2[24]; cf. [3]). To structure knowledge, an ontology was developed as an act of international collaboration of researchers. The ontology constituted the basis to annotate web documents of the knowledge acquisition community in order to enable intelligent access to these documents and to infer implicit knowledge from explicitly stated facts and rules from the ontology. This portal is no longer maintained and even if it is fully based on a ontology its functionality is rather simple (there was no web based administration functionality, for example) and the Information Access layer does not reflect modern user interface conventions and was hard to understand for new users.

Other portals were developed after KA2 was discontinued. Namely parts of the AIFB[25] site are based on semantic web technologies and the Karlsruhe Ontology and Semantic Web Tool Suite (KAON[26]) includes a basic framework for portal creation[27]. Representative for this we evaluated the OntoWeb portal (see section 4.2) as the latest and most matured development of AIFB.

4.5.4 OntoWebEdu[28]

This portals objective is to guide learner to suitable material about Semantic Web using ontology backed search and publication mechanisms. It is part of the deliverables of the OntoWeb Network (see section 4.2). The underlying Ontology only uses of one concept of the OntoWeb ontology (Educational Resource) and the Grounding Technology are realized by two CGI scripts and a conventional web server. Due to its simplicity it was not evaluated in more depth.

5 Comparison

Selected SW portals have been evaluated based on the evaluation scheme and detailed criteria proposed in Section 2 and 3. We have inspected two academic portals - Esperonto portal, Ontoweb – and two commercial portal technology infrastructures – Empolis K42 and Mondeca ITM – more elaborated, and while SWWS portal, Mindswap, Karlsruhe portals, and OntoWebEdu more concisely. The table in the Appendix shows the summarized comparison on the first four portals. In this Section, we will follow the evaluation scheme to provide the overall view on the comparison.

5.1 Grounding Technologies

Grounding technologies contain the key technologies to enable the basic function of the portal, which can be further divided into system technologies and semantic web technologies.

System Technologies

[24] http://ka2portal.aifb.uni-karlsruhe.de/
[25] http://www.aifb.uni-karlsruhe.de/Personen/
[26] http://kaon.semanticweb.org/
[27] http://km.aifb.uni-karlsruhe.de/kaon/Members/rvo/kaon_portal
[28] http://qmir.dcs.qmul.ac.uk/ontoweb/index2.html

Most of the portals take the traditional three tier architecture: a database and / or a file system as backend for data storage layer, Java Servlet based user interface for the front-end, and various server components in the middle tier. For document storage only OntoWeb leveraged existing document management framework functionality (ZOPE). Other evaluated portals just provide simple upload functionality and use the web servers' file system (if at all).

Data transfer has been achieved by either using existing protocols (such as JDBC, SOAP) or home-made solutions like passing serialized Java Objects directly over TCP/IP. None of them has used a fully Service Orientated Architecture (SOA) using, for example, (Semantic) Web Service technology for communication between components (internal as well as external).

Systems are administrated directly via various application servers and operating system mechanisms. Security for information communication is mostly achieved by providing password-protection for registered users or private areas, with methods offered by the employed application server.

Semantic Web Technologies

Semantic features as provided by unique Semantic Web technologies are currently implemented in a limited way, such as providing taxonomy import and export features. Reasons could be the immaturity of Semantic Web technologies and the difficulty of employing them due to technical reasons.

The ontologies used in the portals are normally specifically developed for the according portal, even though some of them are reusing existing ontologies (e.g. the OntoWeb ontology relies on the KA2 ontology. The ontologies' character is more static then dynamic and updates are only allowed to a limited extend; updates simply overwrite existing ontologies and very limited versioning mechanisms are used. None of the portal evaluated offers multi-language support for its ontologies. Inference or reasoning is limited to very low level, mostly restricted to simple inverse, transitive or symmetric properties of ontological concepts or relations.

The control of ontology data and information items is usually handled by different user levels. Normally these are portal administrator (full rights), registered portal members (some rights), and guest visitors (limited rights). Ontologies and instances are maintained separately update by using existing ontology editors such as Protégé2000, or home-made solutions such as WebODE ontology editor (Esperonto portal), OIModeller (Ontoweb), WebAuthor and Ontogen (Empolis K42) and the ITM editor (Mondeca ITM). Empolis K42 and Mondeca ITM are restricted to home made editors after importing the first version of an ontology. Most portals (Esperonto, OntoWeb, Mondeca ITM) support multiple formats for the initial ontology creation and for export of schema and instance data. Some heuristic rules have been added to achieve the consistency – such as when a concept is deleted from the ontology, its instance will become the instances of its super class. None of them provide a sufficient versioning mechanism to trace changes between different versions of the ontology. Also the support for matching instances to a changing ontology schema is very limited as outlined above with the example of the concept deletion.

For internal representation for the ontologies, the academic portals mainly use RDF, the commercial products are mainly based on the Topic Map paradigm. The expressiveness is usually equivalent with a taxonomy structure with relations. More advanced ontological modeling features like cardinality constraints and inference enabling properties like inverseOf are only partly included (e.g. OntoWeb).

Although Semantic Web Services are one of the unique and essential functions provided by Semantic Web technologies, none of the portals evaluated implements or supports them. Future plans of some portals have been already made to further implement semantic web services function to their portals, but no concrete discussion on such issue is available and foreseeable.

Reviewing the state of the art in realization of Grounding Technologies layer in SW portals one of the main challenges is to combine Semantic Web technologies and the already existing classical Content and Document Management Systems. Most of the portals have the focus on the one or the other: Esperonto and k42 clearly put the main emphasis on ontology management. Therefore these emphases result in a less user friendly environment for daily work but on the other hand offer well structured information items. ITM offers connectors to different CMS (although the have to be implemented by the developer of a portal application based on the ITM-technology), also putting the main emphasis on structuring and querying using ontology based techniques. OntoWeb is based on the ZOPE framework and provides a matured User Interface in combination with a set of standard CMS functionalities.

Technically, the challenge is to reuse work out of both areas – the ontology and the document management area. Most approaches use a document as well as an ontology repository and they link data present in both systems, where the ontology repository handles most of the meta data management. On challenge is to keep both repositories always synchronized; so, the harmonization and integration of Semantic Web technologies with existing Content and Document Management Systems and, furthermore, making them become an inseparable unit is a main task and challenge.

5.2 Information Processing

The information processing facilities of an SW portal consist of five life cycle stages: creation, publication, organization, access and maintenance. Each portal varies in the implementation of these phases and borders are often intangible. However, classifying the processing into these steps provides a better base for our comparison.

Note that further explanation reflects to what extend semantic technologies are leveraged, it is not mend as overall judgment, since it does not include usability and the assessment of non semantic web technology to accomplish the tasks in each phase. Note that we especially found the Esperonto portal hard to use, however the underlying ideas reflect a great deal of the potential of semantic web technology.

In all portals investigated in detail, the creation of a new information item is based on HTML-forms which represent the attributes of the corresponding ontology

concept. Usually the assignment of a new item to the ontology is achieved by this implicitly. For the creation of documents there is only limited support in SW portals. Most rely on external editors like Microsoft Word. K42 does not provide complete web based forms for end users. Esperonto portal provides this, but using the information item name as unique identifier, as well as problems to assign property values in one creation step is lowering the usability. OntoWeb does provide complete forms and in addition integrates pre defined ontologies such as DC Core and BibTex, but only ITM also enhances this step with automatic features such as extracting the author name directly from the meta data of an Microsoft word document.

The publication of a new information item is usually divided into the submission by the creator and a validation by the portal administrator. The actual sub-steps in the publication phase vary between the portals, mainly depending on the number of different user levels. Only K42 allows the publication just to administrators. Within our evaluation we found no evidence that any portal interweaves semantic web technology into its publication process.

For access of the information by users, most of the portals provide ontology based navigation or browsing functions. Only ITM does combine this with a full text search of information item content. OntoWeb does not offer full text search and does not interweave the ontology with an thesaurus. K42 offers a wide range on visualization tools, but does not provide an ontological search form as defined in our criteria. Whereas Esperonto does, but due to less extensive usage of visualization (no graphical representation) and technical problems with their key word search the portals usability was reduced.

In the organization phase OntoWeb provides little functionality, since it maps its ontology to a simple object model (ZOPE objects), which does not support rich features like other ontology repositories. K42 and ITM both use self developed repositories, only Esperonto portal leverages the functionalities of a pre existing repository with a well developed set of functionalities like versioning, inferencing, ontology im- and export, etc.

Maintenance is closely related to organization of the information items. Support for collaborative evolution of the ontology schema and easy modification of instance data should be provided. None of the portals had elaborated evolution concepts for the schema. Esperontos underlying ontology system does support versioning but this feature is currently not used within the portal. OntoWeb does not support versioning but has a good integration of changes into the publication workflow. K42 and ITM just overwrite existing information when modifying instance data.

5.3 Information Access

The academic portals are used as the document management and dissemination point for research projects; the commercial ones investigated aim at developers of web portals for different application areas, e.g. a conference portal or a portal solution for Knowledge Management (see demonstration sites of K42 and Mondeca ITM). The portals' usability is mainly limited to creation and maintenance of information within application domains. Many other functions to

facilitate community communication are ignored, such as discussion forum, mailing list archives or referential materials.

The content provided in the portals covers only special application domains without a broader extension to related areas and domains. Except OntoWeb, the portals do not allow personalization of information spaces. Ontology based portals can easily keep high consistency in information access because instances are provided based on an ontology. Basic help and document are provided to facilitate the easy-use of the portal, but there exist much space to improve such functions, especially to guest visitors.

For navigation most approaches directly rely on the conceptual model, i.e. the underlying ontology. They render e.g. tree structures accordingly to the conceptual model. Only SWWS takes a slightly different approach separating this both aspects (navigation and conceptual model) by using an extra ontology for the visualization.

6 Related Work

Semantic Web is a recent and booming research area starting few years ago. Although increasing efforts have been devoted to surveying ontology-related research studies from various aspects, no survey can be found for evaluating SW portals. Here we present and compare with some works done before which have various links to our work here.

[7] conducted extensive survey on current existing ontology library systems. The coverage of this survey is very broad (including almost all the existing ontology library systems) and the focus is ontology management, which is also the key part of the SW portal. Based on this paper, we come out with the evaluation criteria for ontology management part for our portal survey. While our paper's focus is evaluation of SW portal, many other functions besides ontology management have also been evaluated, such as information processing, information access and semantic web services.

[20] 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 this paper is different comparing to our survey, this paper gives us good hint for designing our evaluation schema. We further extend their proposed generic framework for SW portal to include many other functions which we believe also the important features that successful SW portal should bear, such as functional ontology management (editing, browsing & searching, versioning), semantic web services, ontology-powered searching, and information processing workflow.

So from our point of view, our survey on SW portals is quite unique with the respect to the survey coverage and the evaluation scheme provided.

7 Conclusion

Based on the detailed survey of the existing SW portals we realize that SW portals are still at their very early stages. The benefits of implementing these SW technologies can be easily identified or foreseen as Semantic Web technologies have the potential to increase the information consistency and the information processing quality of portals. On the other hand, Semantic Web technologies themselves are still under development and most of the theoretical issues are not easy to be employed into real world applications.

The main benefit of all approaches is to be able to model a portal structure with an ontology. As shown in previous work ontologies are suitable to represent consensus knowledge. Exactly that is needed to exchange information with a community of interest and enable automated processing of information items. Conventional portals try to tackle this problem with various structuring methods like content type, view, proprietary meta data elements, etc. But this often ends up in user confusion and incompatibility with other portals. There exist several methodologies to model ontologies which can be used to create a conceptual structure for a web portal in form of an ontology as the formal representation of a user consensus. The benefit of an SW portal is that it is able to load this initial ontology and build a system out of the box that can satisfy user needs. It will be custom tailored but still be standard compliant.

Reviewing the results in more detail we discovered that the current features available for ontology management have to be further improved; this even holds for the systems building on top of existing ontology infrastructure like Esperonto. Editing, versioning, search and interoperability should be further enhanced. No portal had a mature versioning concept, which deals with for example with changes in the ontology schema and reflects it automatically on the instance level. Also – except Esperonto – most systems assume a single (static) ontology and do not consider interoperability issues between multiple ontologies. Most systems offer basic import and export functionality relaying on RDFS, OWL or Topic Maps, this standardization efforts should be further driven unifying to one standard like OWL.

Also the interoperability between different portals is not evolved. OntoWeb implements this by the RDFS exchange with OntoWebEdu and OntoWebRoadmap in the early stages, but assumes identical ontology structures and so far does not deal with the full heterogeneity of this aspect.

Looking more closely at classical content management facets we have seen that the reuse of mature technology – like OntoWeb does with the ZOPE framework – significantly improves the usability, reliability and scalability. That means a semantic web portal should not be developed from scratch, but reuse existing technologies where possible.

Another aspect which relates to our definition of a SW portal was also mainly neglected: community features that helps building and tightening a group of interest were not implemented, only OntoWeb offers with the personal folder for registered users such a feature. Other features outlined in section 3.2.2, are already implemented in various groupware systems but were not implemented in

any of the portals. Furthermore in general the implementations did not provide a community aware user interface [14], for example they take not into account that some users only occasionally use the portal and get confused by a to complicated interface.

Future development of successful SW portals should focus on not only the above criteria but also on Semantic Web Services which will lift Semantic Web portals to next level. Semantic Web Services transform current web from a distributed source of information to a distributed source of functionality and a web portal is a descent platform to implement this. Various functions provided by current portals can be further refined as services. These services can be automatic located, composed, invocated and interoperated with other services or agents available via the web, which can significantly extend the functionality of the portal.

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Appendix – Summary of SW Portal Evaluation

		Esperonto	Ontoweb	Empolis K42	Mondeca ITM
GROUNDING TECHNOLOGIES					
System Technologies					
Data Manage-ment	Data Storage	Server file system, WebOde platform for ontologies	ZODB (object-database provided by ZOPE)	K42 server (Topic Map Server), file system or RDB as backend system	J2EE component (self developed) as know-ledge repository, different backend systems usable. only accessible via API
	Sorting & Indexing	No.	CMF (Content Manage-ment Framework, part of ZOPE)	No.	Thesaurus-enabled, depends on backend storage system
	Data Transfer	JDBC, RMI	ZOPE application server	Socket connec-tions, serialized Java objects	JDBC, customer-based protocol
System Maintenance	System Administration	Minerva application server	ZOPE application server	TMV application, Java API	depends on backend storage system
	Security Technology	password authentication	different user roles, password authentication	No.	user roles, password authentication
Semantic Web Technologies					
Ontologies	Ontology	5 domain ontologies for IST-Projects (project, documentation, person, organization, meeting)	OntoWeb ontology (application ontology describing all content types of the portal)	Customer dependent	Customer dependent
	Ontology Structure	Ontologies linked through several relations. 5 levels with 2 to 8 concepts on each level. Document Types not included.	OntoWeb ontology: publications, ontology-techniques, events, links, educational resources, 3-4 levels deep.	Comprises model-ling primitives for Topic Maps	Topic Map model contains TM model-ling primitives OWL-ontology for managed data
Inferencing & Reasoning		WAB axiom editor for checking information consistency. Currently axioms can only be executed programmatically	currently no, but extension planed (OWL as format)	Arc Construct (Topic Map Standard) similar to inverse or symmetric property inferencing.	Currently no, but plans for integrating an open source information engine.
Ontology Manage–ment	Editing	Portal Administrators and permitted members can edit the ontology on the instance level via the portal interface and the ontology schema via the WebODE ontology editor	instance level via user interface of ontoweb schema only external	WebAuthor: modify all aspects of topic maps Ontogen: visualize a Topic Map and instance addition	Protege2000 to create ontology externally ITM Editor to edit ontology (not very powerful)

		Esperonto	Ontoweb	Empolis K42	Mondeca ITM
	Maintenance /versioning	A Java Applet (Onto designer) for ontology updates but only very basic versioning support: if a concept is removed from the ontology, its instances become instances of its superclass.	instances maintenance inside the portal by owner / administrator no versioning function is provided	only by administrator tool-support for modification on schema level and instance level no versioning	schema mainte-nance via ITM editor instances addition: by end user (web forms), automatically by linguistic tools, parsing existing metadata no versioning
	Ontology search for Administrator	WebOde platform	Via ontology-browsing in portal	Via ontology-browsing in portal	
	Standardization	WebOD- features: XCARIN, F-logic, RDF(S), OIL, DAML+OIL, OWL	RDF(S), OWL (in the future)	Topic Map ISO / IEC standard	Topic Maps, OWL
Semantic Web Services		No (SOAP & WDSL access function planned).	No (WS inclusion planed for the future) –	–.	No. (support for XML and SOAP, so API migration to WS tech-nology possible)
INFORMATION PROCESSING					
Creation		· restricted to different user levels: administrator, members with appropriate permission. · steps: login, browse, select information type, fill in a form, send, · implicit instance assign-mend to the ontology (´name´ is identifier)	· only registered users · form-based editing support · steps: login, browse, select information type, fill in a form, send, · creation information are divided into: base data, values of properties, metabase	· only by portal developer or administrator · tool support: WebAuthor and Ontogen (s.a.)	· registered user with ´validation´ rights · form based · implicit instance assignment to ontology and to keywords in a thesaurus
Publication		· publication only by restricted user group · no quality control in the middle	· two level of publication: private (visible for owner & administrator), published (to any visitor) · final publication by administrator (quality control)	· only by administrator · concurrent with creation	· quality control by authorized user

	Esperonto	Ontoweb	Empolis K42	Mondeca ITM
Organization	· items stored as ontology instances in WebODE ontology repository · documents are stored in server file system · no indexing	· ontology assignment automatically · all data management handled by ZOPE · partial indexing (only for item descriptions)	· storing and indexing handled by K42 server	· storage in storage system (chosen backend device) · thesaurus- based indexing on keywords (not in demo version)
Access	· keyword based search (only one word, search on item description only) · ontology browsing (to concepts and instances) · ontology-based search (not working properly)	· navigation menus · ontology browsing · combined ontology-based search and keyword based search .	· browse schema and instances via hyperbolic tree or HTML tables · text search on item descriptions	· browsing ontology · keyword searching · semantic searching · graphical navigation (to be extended)
Maintenance	· only by users with adequate permission instance name and description not updatable · item deletion only by administrator · schema modification via WebODE (not possible via portal interface)	· user can maintain own information items in personal folder · administrator can edit, publish, reject, delete any information item · no versioning function is provided	· only by administrator · same tools are usable as for creation (s.a.) · no versioning	· editing possible for different user levels · 2-step process: value-edition, asso-ciation editing (difficult ot use) · no versioning .
Collaboration Features	–	–	–	–
INFORMATION ACCESS				
Usability	· intranet for project management and extranet for dissemination · low usability (only creating and maintaining information within project) · content: deliverables, announcement and news, no referential materials	· information exchange platform for OntoWeb project and Semantic Web community · good ´look & feel´ · high usability, little drawbacks in lucidity and collaboration features · should provide more general references on Semantic Web	· XML Europe 2000 (demonstration): · conference portal, implements basic K42-system · low usability · provides only basic functionality	· -portal for enterprise content organization · good usability: functions to manage ontologies, index and organize content · graphical searching and browsing · no community-centered features

		Esperonto	Ontoweb	Empolis K42	Mondeca ITM
General Assessment as Web Technology	Coverage	· Only project related information	· mostly project related information · more information should be covered and updated timely for broader use.	· conference information (demo site)	· enterprise content management (demo site, does not contain a reasonable amount of information items)
	Maturity of Implementation	· not high maturity · some bugs · site map is still under construction	· nearly complete & stable · search function is still very basic	· stable · not sufficient portal functionality	· fully implemented · mixture of too many similar technologies
	Personalization & Collaboration	· no personalization · good collaboration for constructing ontologies · - no additional collaboration features	· personalized folder · user can easily receive beneficiairies from portal rather than contribute to the community	–	· no content-specific personalization · no support for collaboration and communication
	Consistency in Information Access	· information is quality controlled and reliable. · instances are provided based on ontology so consistency is maintained.	· information quality controlled and reliable · information items are ontology instances, so consistency is given	· information is quality controlled (publication by administrator)	· information is quality controlled (reliable) · ontology develop-ment might cause problems (ontology too embracing)
	Help & Documents	· only brief help is available (not enough especially for guest users)	· popup help is provided · documentation well elaborated	· detailed help page for portal usage · Topic Map introduction	· no help & document-tation (only a demo)

Table 6: Summary of Semantic Web Portal Evaluation