Library portals: toward the semantic Web

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Abstract

The semantic Web is an exciting prospect, but not yet a reality, for researchers who are faced with an ever-increasing range of material – some freely available and some accessible to them only by virtue of their affiliation. This paper introduces the concept of the semantic Web and indicates how, if realized, the semantic Web could be of great benefit to researchers. Some parallel activities now under way are aimed at providing practical solutions to scholars today through the use of agent technology built into library portals; the paper explains, in particular, how one system, MetaLib – the library portal solution from Ex Libris – addresses these issues.

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Introduction

The scholarly information arena offers researchers an ever-increasing array of resources. Researchers are likely to find material relevant to their subject in a variety of Web-based resources: their own library's catalogue; catalogues outside their own library, such as a national or union catalogue or a catalogue of another institution that specializes in similar subjects; reference databases, such as an abstracting and indexing database or citation database; full-text resources; digital repositories; and Web pages. The current process of accessing several resources for the sake of seeking information is cumbersome and requires some knowledge of the various resources, their access mechanisms, the query interface they provide, and the type of results they return. It also requires a manual comparison between the results returned from several resources and does not enable the user to move from one resource to another for further discovery and navigation.

Significant efforts are under way to address these issues, not just for scholarly information but also for all Web-accessible data. Of particular interest are the semantic Web developments spearheaded by Tim Berners-Lee and the World Wide Web Consortium (W3C). W3C is the acknowledged organization for the creation, maintenance, and promotion of Web standards. The semantic Web work shows clear promise, but pending the adoption of the emerging standards, independent intelligent tools are required for integrated access across heterogeneous resources.

The semantic Web

To a user, the Web is an exciting place: a set of interconnected resources and links. The user is typically able to grasp the meaning of a document and determine its relevance by viewing that document. A machine, however, cannot readily interpret this information; yet machine-driven or automated processes are required to facilitate access to the plethora of information on the Web.

The semantic Web is now emerging to address precisely this issue and offers a vision for the future in which the explicit meanings given to information make the processing and integration of Web-based information easier for machines to carry out automatically: "The Semantic Web is not a separate Web but an extension of the current one, in which information is given well-defined meaning, better enabling computers and people to work in cooperation" (Berners-Lee *et al.*, 2001). Planned to take advantage of the Resource Description Framework (RDF) and additional standards, the semantic Web is being developed by the W3C in collaboration with a large number of researchers and industrial partners (RDF, 2002) (W3C, 2001).

Still at a relatively early stage, the development of the semantic Web is building on existing Web technologies that use the ability of XML data representation to define customized tagging schemes and that take advantage of the flexible approach adopted by the RDF for the representation of data. RDF provides a common framework for representing metadata across many applications.

The next element required for the semantic Web is a Web ontology language that can formally describe the semantics of classes in the many domains of interest and the semantics of properties (or attributes) used in Web documents. Ontologies provide richer integration and interoperability of data and permit the development of applications that search across diverse communities or merge information from them. Through the use of ontologies, tomorrow's applications will be "intelligent": they will work more accurately at the human conceptual level. Ontologies will be used to improve existing Web-based applications and may also bring about new uses of the Web.

Some initial work toward the development of ontologies is proceeding in the Web portal environment; for example, the OntoWeb project at the Free University of Amsterdam. OntoWeb serves the academic and industrial communities that are interested in ontology research (OntoWeb, n.d.).

Web portals

One of the many useful applications of the Web is Web portals, often referred to simply as portals. A portal is a Web site or Web service that provides information content to serve a specific community. Web portals include wide-reaching online services such as AOL or MSN, as well as services targeted at very specific communities – for example, a community interested in cancer research. A universal aspect of Web portals, however, is that they allow individuals to receive news, find and talk to one another, build a community, and find links to other Web resources of common interest. "In order for a portal to be successful", write Karvounarakis *et al.* (2001), "it must be a starting place for locating interesting content. Typically this content is submitted by members of the community, who often index it under some subtopic. Another means of collecting content relies on the content providers tagging the content with information that can be used in syndicating it". Typically, this tagging would involve the creation of simple tags that identify the topic of the content.

However, such indexing may not be sufficient to meet the needs of the portal community, and so to allow a more intelligent syndication of the content, Web portals would define a Web ontology language for the community. Content providers would then need to annotate their pages with this Web ontology language so that users would be able to obtain search results that are not accessible through conventional retrieval systems.

The next step in the evolution of the Web – the semantic Web – will make available vast quantities of information resources (data, documents, and programs) along with various kinds of descriptive information (metadata). This step will open new perspectives for community Web portals. Increased knowledge about the meaning, usage, accessibility, and quality of Web resources will considerably facilitate the automated processing of available Web content and services.

Library portals

Library portals, the focus of this paper, are a subset of Web portals and serve specific academic research communities. Libraries – digital libraries in particular – are important memory organizations that form a keystone for the development of the semantic Web (Miller, 2001).

Available for some time now, library portals typically provide a gateway to an institution's resources by listing them for users and creating a direct link to the native interface of

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each resource. Such listings are available on most library Web sites today, although many sites provide only alphabetic listings; some sites – though few – do provide resource discovery facilities to help users identify the most appropriate resources for their searches. A relatively new feature enables users to employ a library portal's search interface to search simultaneously or sequentially in heterogeneous resources that do not share metadata schemes or search-and-retrieval techniques.

This new search capability in library portals deals with the deep Web, drilling down into database content that the standard Web engines do not reach. Such deep Web content can be freely available resources, such as the PubMed abstracting and indexing database from the National Library of Medicine, in the USA, or licensed resources for which a subscription is required (PubMed, n.d.).

According to Mary Jackson, of the Association of Research Libraries (ARL) in the USA, the integrated, cross-database searching through a wide range of resources will be the core feature of library portals as they become more entrenched (Jackson, 2002). However, in the absence of standards, developing capabilities for such unified searching across heterogeneous resources presents a number of challenges, which proponents of the semantic Web are currently addressing.

Federated (cross-database) searching

Accessing a resource for the sake of querying it or obtaining results from it requires prior knowledge of the resource, because each resource has its own distinct structures and rules for the interpretation of its data. In reference to the semantic Web, Berners-Lee *et al.* (2001) state that "a typical process will involve the creation of a 'value chain' in which subassemblies of information are passed from one agent to another, each one 'adding value', to construct the final product requested by the end user". This, indeed, is the vision, but as already mentioned, today's Web does not allow such interaction between agents, and, therefore, an automated interaction between the central unit of a portal and a search engine at the resource end cannot be achieved at the present time.

It is not only the structure of the data at the target end that is required for the delivery of queries and the retrieval of results. Rules for the construction of search terms and the flow of the search and retrieval also need to be provided. According to Berners-Lee *et al.* (2001), "the challenge of the semantic Web, therefore, is to provide a language that expresses both data and rules for reasoning about the data and that allows rules from any existing knowledge representation system to be exported onto the Web".

Even before the materialization of the Web as a ubiquitous entity, a standard did emerge from the library world to permit searching and retrieval across a range of diverse resources – Z39.50. This international standard governs communication between computer systems, primarily those related to libraries and information systems. Z39.50 was developed as a point-to-point client-server mechanism and works optimally in locating records in one or more databases on a single server. However, specific information must be known about both the server and database, and particularly about the structure of the contents of the database.

The Z39.50 Explain facility was developed by the Z39.50 community to address these problems. It offers a structured mechanism that enables the information provider to publish information not only about the capabilities of the server software but also about the characteristics of the information stored in each database on the server. Sebastian Hammer, of Index Data, and John Fayaro, of Intecs Sistemi, developers of Z39.50 applications, comment that "the rigid structuring of the information allows the client software to automatically configure itself and adapt to each server system, while the uniform interface to the descriptive information about the database helps the user quickly orient himself to the contents of a new information resource" (Hammer and Fayaro, 1996).

However, despite the optimistic predictions of Hammer and Fayaro in 1996, fewer than 1 percent of Z39.50 servers had implemented the Explain facility by June 2000 (Bull, 2000). It is doubtful that there has been a significant increase since June 2000. Programs that relied on the Explain function, therefore, also had to provide other ways in which resource interaction could be implemented in case the data provider did not support that function at all or supported it only partially.

Some new developments from the Z39.50 community promise to simplify the Explain facility, which may then become more widely adopted. With the Search and Retrieve Web Service (SRW) that the Z39.50 International Next Generation (ZING, n.d.) group has defined, no distinction will be made between a server and a database. It is hoped that the elimination of the database concept will bring about significant simplification.

One of the major challenges for library portals is to make interaction possible between a portal and any number of target resources without requiring prior programming for each target resource. The ideal solution is to receive resource-specific information at the time of the actual interaction – as envisioned by the promoters of the Z39.50 Explain facility – and formulate the flow of the interaction on the basis of this information. However, the manner in which resources have been handled up to now has precluded the realization of such a solution. A more practical solution is to create a repository that is able to emulate such a setup; that is, that contains the information required to access the resources that the portal seeks to reach. Such repositories can be viewed as containing the deep Web ontologies. Indeed, the emerging generation of library portals relies on a repository of this nature. MetaLib, the library portal solution from Ex Libris, has followed this route with the repository known as the MetaLib KnowledgeBase; the MetaLib software itself, specifically the Universal Gateway component, remains free of resource-specific references.

MetaLib, the library portal from Ex Libris

Built as a generic program, the MetaLib Universal Gateway does not depend on any specific resource. The repository – the MetaLib KnowledgeBase – provides the necessary information about the entire interaction with the target resource and enables the Universal Gateway to follow the rules and understand the structures that were set by that specific resource. The KnowledgeBase can contain references to other repositories that can be used as subdescriptions. For instance, the KnowledgeBase can refer to a description of the MARC standard rather than containing the description itself. Once the Web has become more developed and this type of information is available, the repository will be replaced by the information it receives from resources on the fly and the Universal Gateway program will not need to undergo any changes.

The information in the KnowledgeBase serves an additional goal – it provides resource discovery features for locating resources for a specific query. Currently, when a query is invoked, the selection of the target resources must be made by a human – typically a user, but possibly a reference librarian who "pushes" the list of resources to the user. The selection of resources by humans will probably continue until software agents that can interact with each other are available. Then one agent will be able to find others that are capable of giving the best results for a specific query. MetaLib also uses the information in the KnowledgeBase to render the process of resource selection friendlier and smoother for both reference librarians and end users.

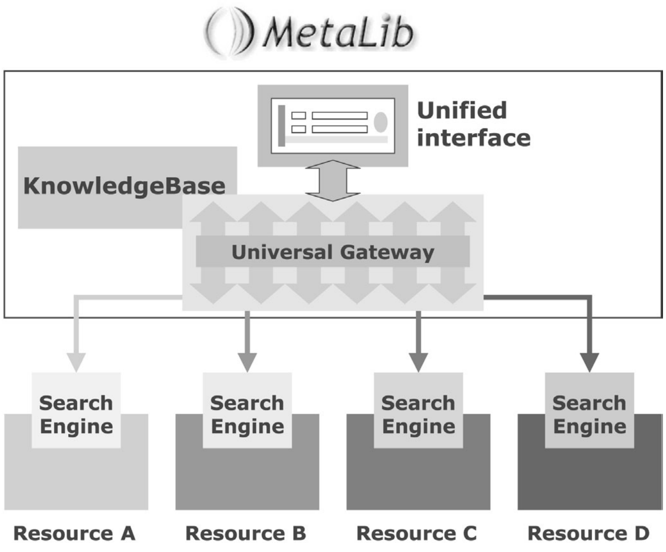
Configuring the MetaLib library portal

As previously explained, MetaLib, like other library portal products, makes use of an underlying data repository. The MetaLib KnowledgeBase stores information about the resources available to an institution. Each resource that can be searched via MetaLib is represented by an entry in the KnowledgeBase.

The storage of information at several levels accommodates the centralized, worldwide KnowledgeBase, which serves as a basis for local installations. The challenge is to allow updates from a centralized source while storing locally maintained information at each site. Web-based tools come along with the repository to permit the creation and maintenance of target-resource entities, the import and export of information, the adaptation of the information for a site or a unit within a site, and the provision of such information to both humans and programs as necessary (see Figure 1).

Two types of information are stored in the KnowledgeBase, descriptive and functional. Whereas the functional information permits

Figure 1 The MetaLib Universal Gateway interacts with the various target resources to provide the user with results; the interaction is based on the data and rules stored in the KnowledgeBase



interaction between the Universal Gateway and the resources for search and retrieval functions, the descriptive information enables the portal, through an additional layer of resource metadata, to help users locate relevant resources.

Descriptive information

From the point of view of descriptive information, the KnowledgeBase is a collection of metadata about resources. Each resource is catalogued in the KnowledgeBase, typically as the result of collaboration between Ex Libris, a representative party at the institutional end, and sometimes also members of the institution, each of whom adds observations and objectives. The interest of librarians in the organization of such information can be demonstrated in several recent initiatives, such as the UK Collection Descriptive Focus, jointly funded by the British Library, the Joint Information Systems Committee, the Research Support Libraries Programme, and Resource (UKOLN, 2002).

This descriptive information enables a researcher, for example, to locate the resources relevant to a certain subject. Librarians use the descriptive information as a tool to present the institution's collection in a comprehensive way. Besides providing users with informative, objective data such as the coverage of the specific resource and its language, librarians categorize resources and assign keywords to them to present them in the right context for the specific user. The librarians can push resources to a user on the basis of the user's group affiliation.

The MetaLib software employs the resources' metadata to enable users to locate resources that are of interest. For instance, a default resource list compiled by a librarian forms the basis of a personal list belonging to a law student. This law student can then modify the list and add other resources of interest. When looking for information, the student can select resources from his/her personal list or use MetaLib Resource Locator or Resource Browser to locate resources for the specific query. This student can also choose to work with one of the predefined lists that the librarian has defined for the entire institution.

The descriptive information in the MetaLib KnowledgeBase is set by humans, for humans. Presenting a large number of resources to end users is not an easy task, and institutions are clearly struggling to provide friendly interfaces that expose their collection in a way that helps people find what they need. Any solution based on static HTML pages is difficult to present and maintain because of the frequent changes in the set of resources and in each resource itself. Furthermore, many resources can be associated with more than one discipline or context, so any update needs to be implemented accordingly.

Stored in the KnowledgeBase for each target resource, the descriptive information permits the dynamic display of the resource in any context, without any modification to a program or HTML code. When a new resource is added to the system, the resource is presented to the user whenever relevant, from that moment on.

The descriptive information component in the KnowledgeBase includes such general data as the full name of the specific resource, alternative names, the vendor's access policy (whether the resource is free or by subscription only), the type (such as a library catalogue, abstracting and indexing database, or Web search engine), the creator, and the publisher. Obviously, a description of the resource and its coverage, time span, and languages – all of which are typically centrally defined – are also included.

Additional information can be determined according to local needs. Such information includes how the resources are to be categorized for presentation to users, user entitlements, and authorization attributes for access to resources.

The descriptive information in the KnowledgeBase is a function of an institution's resource environment and is made possible through the persistent nature of this repository, which falls under the institution's jurisdiction. Once library portals reach a point where the target resources expose the structure and inference rules regarding their own data and software capabilities, the functionality of this layer of institution-sensitive information will be reassessed.

Most of the descriptive information is available to users, either explicitly or implicitly. At any stage, a user can ask for information about a resource. When searching for a specific resource, the user may wish to see the resources displayed by category and may take advantage of the stored information. Users are shown only the resources that the authorization rules set by the library permit them to see.

Functional information

The functional information in the KnowledgeBase for each resource includes:

- Information that sets the rules for the transfer of a query. This information is provided on three levels: the method of transfer (such as server-to-server interaction or HTTP); the format in which the query is transferred (for example, it can be sent as a Z39.50 query or as an HTTP request, which is either formatted as a URL or sent in an XML document); and the construction of the query itself. The latter involves issues such as the adaptation of the query syntax, mapping of search indices, and character conversions.
- Information that sets the rules for the interpretation of the results obtained from the resource. This information resembles the query information and includes the rules that permit the interpretation of records that differ in their physical and logical structures, cataloguing formats (such as MARC and MAB), and character sets. Once the records are interpreted and converted into a unified internal format, machine-driven tools can display all the results to the user in the same manner, compare records that originate from disparate resources, provide services relevant to specific records, and more. With the interpretation of the results, the groundwork is set for the creation of an OpenURL for onward linking.

The emerging NISO OpenURL standard (NISO Committee, AX, n.d.) enables an institutional linking server such as SFX to provide context-sensitive links to appropriate services and related resources. Once the metadata obtained from the resources is interpreted, an OpenURL can be generated and delivered to the institution's linking server at the user's request. The linking server can then evaluate the metadata and, according to the user's affiliation, offer the user a set of links as configured by the institution (Van de Sompel and Beit-Arie, 2001).

In addition to the elements just described, the functional information of the KnowledgeBase contains a set of rules that must be sequentially executed by a program to accomplish the task at hand; that is, the transfer of a query and the processing of the results. Conversion tables that help the program interpret the rules that it encounters complement this set of rules.

The functional information component enables MetaLib to have one interfacing program that interprets the rules for each specific resource and acts according to these rules for both the querying and processing of the retrieved data.

Rules that apply to queries

Berners-Lee *et al.* (2001) state that "for the semantic Web to function, computers must have access to structured collections of information and sets of inference rules that they can use to conduct automated reasoning". A feasible example of the implementation of such inference rules is the use of a set of transformations to convert the user query into a format that matches the specification of the target's search engine.

Let us look at a simple illustration. A certain target resource requires that the author's name in a query take the following form:

<LAST NAME>-<FIRST INITIAL>?

If a user enters a name as "smith, john" (in the MetaLib search syntax), the name has to be converted to "SMITH-J?". In the

KnowledgeBase, the following transformations, that is, rules that the Universal Gateway executes sequentially, are assigned to the specific resource:

(1) Change the case of the string from lower to upper.
(2) Remove the comma.
(3) Truncate the last word; leave only the first letter.
(4) Replace the space between the two words with a hyphen.
(5) Concatenate a question mark at the end.

By making such rules available, MetaLib exposes the logic of the transformation process and makes the process easier for librarians to follow and correct as necessary – unlike programming routines that resemble a black box. A librarian with no knowledge of programming can set the rules that apply to a certain resource; the program then activates the rules to create a query and follows the steps that are expected at the target end. The next phase that is planned for MetaLib is for the librarian to specify only the expected outcome and the agent to determine which rules to apply (see Figure 2).

Rules that apply to the processing of results for standardized display

The processing of results is no less complicated than the broadcasting of a query. Once records are retrieved, their format needs to be converted into a common internal format. Conversion of all the results into a unified format provides several benefits:

- A unified display of the records, regardless of the native interface of the target resource.
- A comparison of records, which permits sorting and ranking as well as the merging and de-duplication of lists of results, even though records in those lists may originate from heterogeneous resources.
- The construction of an OpenURL, which allows the generation of context-sensitive links to various services.

Again, the processing of the results requires that a set of rules be followed, rules that enable the software to map the fields correctly, convert character sets, parse fields to extract the metadata relevant to the generation of an OpenURL, and so on.

Let us look at an example of rules that apply to a resource in which citation information is represented in a single field. In this case, the program needs to extract the ISSN (or journal name), year, volume, issue, and start page from that field in order to present a more convenient display format and to identify the metadata elements required for the OpenURL.

Presumably, the field looks like this:

<journal abbreviated name> <month>/<month><year>, Vol. <volume> Issue <issue>, p<page>

Here are two examples of such citations:

Macrobiotics Today May/Jun2002, Vol. 42 Issue 3, p25

Health Jun2002, Vol. 16 Issue 5, p120

The librarian activates the following rules to extract the necessary information (see Figure 3):

(1) The journal name is in the first position and ends before the name of a month.
(2) The name of a month is followed by a year if there is no "/". The year has four digits.
(3) After the string "Vol." comes the volume number, which is followed by a space.
(4) After the string "Issue" comes the issue number, which is followed by a space.
(5) The string ", p" is followed immediately by the start page number.

Figure 2 A single query is delivered to heterogeneous resources and adapted as needed for each

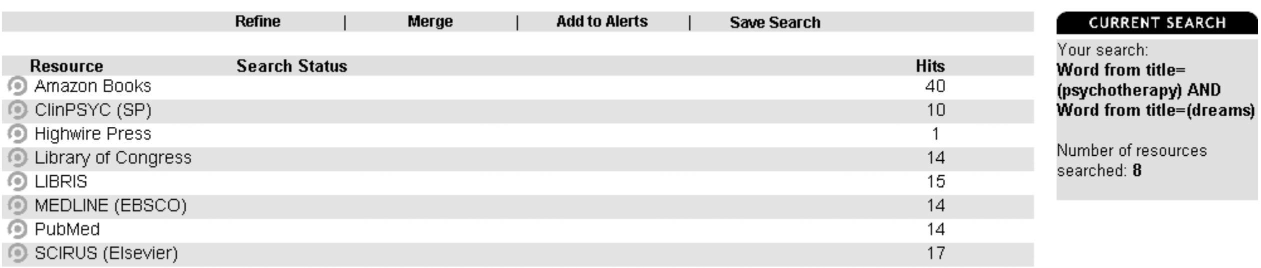


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Figure 3 A unified display is feasible once the retrieved records are interpreted according to the functional information saved in the KnowledgeBase

Resource	◆ LIBRIS
Title	◆ Inter views : of **psychotherapy**, biography, love, soul, **dreams**, work, imagination, and the state of the culture / by James Hillman with Laura Pozzo
Author	◆ Hillman, James
Add.Author/Editor	◆ Pozzo, Laura
YEAR	1991
Subject	◆ Hillman, James Interviews
	◆ Psychoanalysis
	◆ Psychology
	◆ Psychoanalysts Interviews
	◆ Psykoanalys
	◆ Intervju
	◆ Psykoanalytiker
ISBN	0-88214-348-4(pbk.) CIP rev. : $15.50
Note	Reprint. Originally published: New York : Harper & Row, c1983
Dewey no.	150
	150
Imprint	Woodstock, Conn. : Spring Publications , 1991, cop. 1983.
Description	viii, 198 s. 23 cm
Bibliogr.	Includes index
Add.Title	Interviews
Holdings	P P 96:585

Resource	◆ PubMed
Title	◆ The use of **dreams** in **psychotherapy**: a survey of psychotherapists in private practice.
Author	◆ Schredl M
	◆ Bohusch C
	◆ Kahl J
	◆ Mader A
	◆ Somesan A
Citation	J Psychother Pract Res 2000 Spring;9(2):81-7.
YEAR	2000 Spring
Abstract	Since the publication of Sigmund Freud's The Interpretation of **Dreams**, dream interpretation has been a standard technique often used in **psychotherapy**. However, empirical studies about the frequency of working on **dreams** in therapy are lacking. The present study elicited, via a self-developed questionnaire, various aspects of work on **dreams** applied by psychotherapists in private practice. The findings indicate that **dreams** were often used in therapy, especially in psychoanalysis. In addition, a significant relationship was found between the frequency of the therapists' working on their own **dreams** and frequency of work on **dreams** in therapy. Because work on **dreams** was rated as beneficial for the clients, further studies investigating the effectiveness and the process of working on **dreams** will be of interest.
Subject	◆ Behavior Therapy
	◆ Data Collection
	◆ ***Dreams**
	◆ Female
	◆ Germany
	◆ Human
	◆ Male
	◆ Psychoanalytic Therapy
	◆ **Psychotherapy**/*methods
ISSN	1055-050X

Resource	◆ ClinPSYC (SP)
Title	◆ **Dreams** and nightmares about the next big revolution in **psychotherapy.**
Author	◆ Beutler,-Larry-E
Citation	**Psychotherapy**:-Theory,-Research,-Practice,-Training. 2000 Win; Vol 37(4): 359-363
YEAR	2000
Abstract	The future of **psychotherapy** as a part of psychological practice is yet to be written, but there are both ominous and hopeful signs to which we must attend if we wish to avoid the pitfalls of the past and to write a positive history. The present is the future that we dreamed of 20 years ago. At that time, psychologists concerns with being included as health providers launched **psychotherapy** on a path that has had both positive and negative effects on our growth. The consequences included current struggles with managed healthcare. The current infatuation with obtaining prescription authority threatens to move us further down this road, to take us further from our strengths as a research-minded, psychological discipline, and to further fractionate outfield. Thus, the next revolution in **psychotherapy** could be either a nightmare or a dream, depending on whether we honor or disavow our strengths. (PsycINFO Database Record (c) 2002 APA, all rights reserved)(journal abstract)
Subject	◆ *Future-
	◆ ***Psychotherapy-**
	◆ History-of-Psychology
	◆ Human
ISSN	0033-3204
Imprint	US: Div of **Psychotherapy** APA.
Type	Journal-Article
Biograph. note	Beutler,-Larry-E: U California, Dept of Education, Counseling/Clinical/School Psychology Program, Santa Barbara, CA, US
Language Note	English

Setting up a new resource, then, requires that the appropriate rules be assigned. Either Ex Libris can set up new resources and make them available, or librarians can add resources locally and edit rules when necessary. The process does not require the writing of a program. Rather than containing hundreds or thousands of programs that interpret records for each resource, MetaLib provides the KnowledgeBase, on one hand, and the Universal Gateway, on the other. The latter is a sophisticated program that "understands" the nature of each resource and follows the rules it finds in the KnowledgeBase. As summarized by Berners-Lee *et al.* (2001): "The computer doesn't truly 'understand' any of this information, but it can now manipulate the terms much more effectively in ways that are useful and meaningful to the human user".

Conclusion

The challenge for providers of library portal technology such as MetaLib is to provide solutions that will work today, despite the lack of standards, and yet are prepared for the promise of the semantic Web.

Through the use of agent technology, MetaLib has demonstrated at sites around the world that the concept underlying the Semantic Web can, indeed, be brought to fruition. Examples of the numerous implementations can be viewed on the Web (Boston College, Massachusetts, USA – http://metaquest.bc.edu/V), (CASLIN (the Czech National Library, Czech Republic – http://octopus.ruk.cuni.cz Czech Reublic V)), (Curtin (Curtin University, Australia – http://gecko.curtin.edu.au/V)), (KOBV (Cooperative Library Network Berlin-Brandenburg, Germany – http://search.kobv.de/V)), (UEA (University of East

Anglia, UK – http://mlsfx.lib.uea.ac.uk/V)). The KnowledgeBase repository has proven to be a practical and maintainable method of implementing this concept in the interim. The structure of the KnowledgeBase and the functionality that comes along with it have enabled libraries to set up their portals rapidly, take advantage of the central KnowledgeBase as a basis for their interaction with resources, and add their context and administrative requirements to it. Furthermore, the KnowledgeBase itself represents a potentially valuable resource that programs can access in a non-MetaLib context to extract information stored therein.

Building an application in the manner in which MetaLib has been designed is an important step toward the deployment of the semantic Web concept in the scholarly environment. A greater step will be the construction of resource information such that it will be usable in the future. This step presents a sizable challenge for vendors, as no one can predict just how things will look five to ten years down the road.

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Further reading

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