

Searching Heterogeneous e-Learning Resources

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Abstract. Resource discovery supports the core functions of virtual learning environments and digital repository systems. The function enables existing resources to be identified and re-purposed for teaching. This paper describes the purpose and the development of a search service developed within a project funded by the UK Joint Information Systems Committee (JISC). The search service corresponds to an emerging framework for implementing e-learning web services. It mediates resource discovery among distributed and heterogeneous repositories via a service-oriented approach. This paper provides a review of the e-learning technical framework, and discusses the development of the service along with the application scenarios in which it has been deployed.

1. Service-Oriented Approach and e-Learning

A main challenge in delivering high quality e-learning has been the provision of an infrastructure that is capable of fulfilling the diverse requirements of educational processes. Current developments of e-learning infrastructures involve an increased adoption of service-oriented and distributed computing technologies. The Grid, for example, has become a prominent area of development. As an advanced form of resources-sharing and service-oriented network infrastructure originally developed for e-science purposes, e.g. the Enabling Grid for E-science (EGEE) project (<http://public.eu-egee.org/>), it can be harnessed to fulfill the diverse demands of effective e-learning processes. The European Learning Grid Infrastructure (EleGI) project is one such initiative as it aims to investigate and develop software architecture and prototypes underpinned by the Grid for advanced e-learning paradigms such as socio-constructivism [3, 4].

A service-oriented approach in general involves deriving web services from decomposing the functional components of legacy and monolithic systems. For example, intrinsic parts of virtual learning environments (VLEs), student record systems and library management systems may be unbundled and exposed such that a variety of

educational processes, particularly those of a cross-organisational nature, can be better facilitated through custom-built platforms that are built upon the “orchestration” of these loosely coupled services, along with any new service components required to enhance the processes.

The E-Learning Framework (ELF) (<http://www.elframework.org>) is a collaborative initiative to build a common approach for service-oriented developments [11,12]. It has produced a technical framework identifying a broad set of e-learning services in two categories of functional granularity: Learning Domains Services and Common Services. The former are learning-specific (assessment, course management, resource lists etc.), while the latter identify the underpinning cross-domain support services that are shareable among the learning domain services such as search and authentication. ELF also maps each of the services to the existing or emerging technical standards and interfaces to encourage the adoption of standards and interoperability among the service components. This paper discusses one of ELF’s common services – *federated-search* - and its development within d+, a project funded by JISC [7].

2. Search Service for Heterogeneous Repositories

E-Learning resources can be broadly defined as physical and digital resources that are applicable to course contexts. While some of these resources may include web sites, for example, accessible via search engines such as Google, most reside in digital repositories, VLEs and dedicated portals such as the RDN. Given the widespread use of Google, federated-searching (across multiple data sources simultaneously) is fast becoming the most popular approach to resource discovery available to users. However, unifying accesses to heterogeneous repositories is generally hindered by the information environment that caters for the access to such a diverse range of resources, since the environment is fragmented and typified by widely distributed and autonomously maintained services. These are in effect ‘information ‘islands’, unconnected to an available common source (examples include the list of databases in a digital library [1,2]). Users are confronted with multiple user-interfaces (UI) each requiring familiarisation. Efforts to bridge these information islands remain a challenge due to the heterogeneity of repositories and access methods, where these exist.

Although rarely built into the native functionality of most VLEs, federated searching of external resources is essential. For example, the existing digital resources from the library may be searched from within a VLE, repurposed and augmented with annotations, as reading lists for various course context usages. Such cross-domain use scenarios require more fine-grained integration of the heterogeneous systems beyond the shallow UI-level integration such as linking to (framing) the front-page of a library system. The search service should be accessible from within the VLE in a context that is consistent with educational processes, embedded at the appropriate junctures of learning activities and attuned to different learning outcomes as intended by the instructors. For example, a generic search tool that is used for information discovery and therefore suitable for a constructivist learning style may be cumbersome to

provide for other e-learning scenarios, e.g. embedding it as a subject of discussion in an online forum.

The search service discussed in this paper, the d+ search service, is part of the ELF common services corresponding to the infrastructure-type services which are shareable across e-learning applications. The following ELF common services are related to resource discovery, as described by the ELF initiative:

- Search: supports the finding of information resources including learning objects, assets, e-reserves, learning opportunities, funding sources and so on
- Federated search: supports the processing of searches that target multiple types of repository, such as a combined search using SRW, XQuery and Z39.50 protocols against repositories supporting a range of different metadata formats, the results from which are then aggregated for presentation to the consumer
- Resolver: provides services based on the use of OpenURL (or similar) metadata, including redirection to document delivery services, redirection to online bookshops, to local library services, and other discovery activities

The federated search service addresses the fragmentation by focusing on the ‘intra-function’ interoperability of repositories, i.e. providing a single service-interface search functionality that is interoperable across multiple repositories [2]. It also corresponds to the reference models identified by the IMS Digital Repository Interoperability Specification: *search/expose* for the searching of metadata [5]. Part of the ELF common services also overlap and correspond to the similar infrastructure-type services of frameworks from other sectors, particularly the digital library field. This includes the shared services of the JISC Information Environment Architecture and the emerging JCSR (JISC Committee For Supporting Research) e-research framework. Since the rationale of deriving these services from these different frameworks is the same, i.e. re-factoring common services that are shareable across applications, it is anticipated that there will be initiatives to harmonise and consolidate the services across these different initiatives such that the common services are shareable not only among applications within a specific domain, but also across the different domains, e.g. providing for a common search service for both e-learning and digital library purposes. This will be a welcome improvement. Academics and learning technologists who build learning environments wish to improve and enhance the learning experience of students by including search options generally only available via library portals, and librarians want to expand the range of content available through their portals in order to bring as much relevant material as possible into scope.

3. Implementation

The search service of the d+ project aims to provide a machine interface as a simplified and unified means for searching the following type of repositories:

- Standard Z39.50, SRW/U bibliographic databases.

- EDINA Xgrain/GetRef, a standard (Z39.50) target with additional facilities including parallel searching of multiple bibliographic databases and fine-grained session controls.
- Open-source institutional repositories: Dspace.
- Learning object repositories: IntraLibrary.
- Proprietary resource gateways and catalogue including PudMed, Amazon, Google and O'Reilly Safari e-reference library.

The search interface is based on the Search and Retrieve URL (SRU) – a service protocol that enables search queries to be sent via the web (using REST-type HTTP/URL calls) and results to be retrieved in various XML formats [8]. The search service addresses the following types of interoperability:

- **Access protocols.** The search service delegates requests to a set of repository adapters, each translating SRU into native search functions accessible via various search interfaces including Z39.50 (various), API (DSpace, Google), REST (Safari O'Reilly, PubMed, Amazon) and Web Services (IntraLibrary).
- **Metadata schemas.** Metadata retrieved from different repositories conforms to a variety of native schemas. The search service maps the native metadata according to IEEE Learning Object Metadata (LOM), IMS Resource List Interoperability Specification (RLI) [6] and Dublin Core (DC) metadata schemas. LOM and RLI are suitable for e-learning tools and VLE application contexts; DC and RLI are suitable for generic and library application usage.

Using the toolkit piloted by the project, the search service can be deployed on a Java application server such as Tomcat. The Java-based toolkit consists of a core web services application component which is based on the OCLC SRU reference software [9]. It integrates with the newly developed repository adapters for accessing the repositories described above and uses an existing middleware component, i.e. the JAFER toolkit (<http://www.jafer.org>) for searching Z39.50 repositories. The toolkit deals with SRU requests, metadata mapping and repository access interoperability issues, as described above. The toolkit also consists of a reference SRU services consumer, i.e. a demonstrator web application providing a basic search facility which is built upon the SRU service. The demonstrator provides additional system resources including stylesheets for rendering the search results into web pages.

4. Use Scenarios

Both the d+ search service (setup by a 3rd party) and toolkit can be utilised to support a range of resource discovery applications. Some of the feasible use scenarios are described below.

VLE integration. The search service enables resources (books, journals, articles, and web sites) from various repositories to be seamlessly cross-searched. It bypasses the multiple user interfaces of native repository systems and maps the search results to XML which can subsequently be rendered in a coherent (often minimalist) format suitable for embedding in a VLE (see Figure 1).

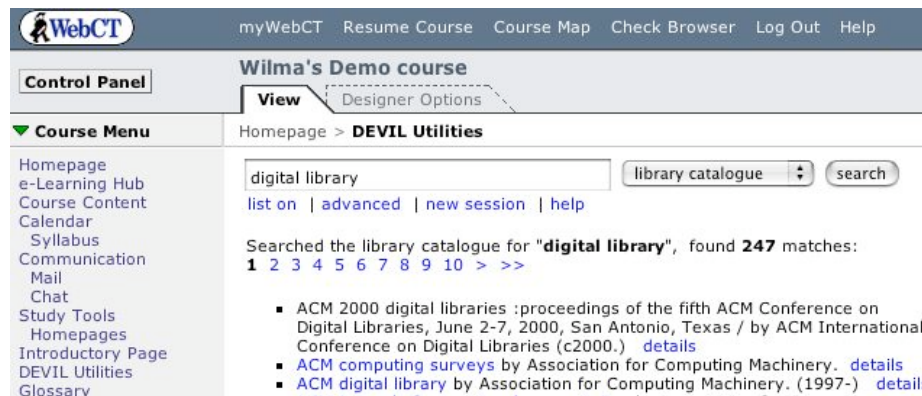


Fig. 1. VLE consuming the ELF search services and embedding the search result in a consistent presentation.

Portal integration. The availability of wireless broadband (Wi-Fi) internet hot-spots means that there is an increasing demand for portals developed specifically for Personal Digital Assistants (PDA). A minimised portal customised to the screen size of a PDA display can be developed (see Figure 2 for a basic search facility currently piloted at Edinburgh University Library which allows searching of library catalogues, peer-reviewed websites and journal articles to be downloaded directly into the PDA for reading).

Metadata enrichment. The service can mediate the fusion of metadata from distributed sources for metadata enrichment purposes. For example, electronic book metadata can be created from a dynamic (runtime) combination of library bibliographic metadata and user annotations retrieved from Amazon¹

¹<http://devil.lib.ed.ac.uk:8080/informaticsportal/resolver.jsp?sid=libraryplus&id=12006>



Fig. 2. A PDA portal based on the ELF service (<http://tweed.lib.ed.ac.uk:8080/pda>)

Conclusion

Resource discovery has been overlooked as a function of virtual learning environments by vendors. Recent digital library work based on open architectures and web services has allowed the initially closed environments of VLEs to be opened in order to allow library resources to be searched dynamically, with result sets made consistent through metadata mapping, and capable of being displayed in a variety of portal interfaces. In this way, library services have been proactively developed in order to be flexibly retro-

fitted to learning environments. The value of the service oriented approach has been proved, and user studies have encouraged further development, which is likely to include enrichment of discovered resources with user annotation and other useful information, as well as putting resources into appropriate use contexts such as reading lists.

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