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Editor's Note: Many years ago I attended a meeting at Stanford University where Steve Jobs did his first public demonstration of the NEXT computer. He amazed his audience by selecting a series of visual objects, each of which functioned like a part in a machine. By drawing lines between them on the screen, he made them function together as one machine where the functions integrated seamlessly. These were reusable objects designed to function in any context. The same principles are applied in Object Oriented (computer) Programming, which combines modules to create larger programs. Similar principles build custom learning experiences using Learning Objects.

An alliance of Canadian Universities and government agencies pooled their resources to establish a network to share and combine Learning Objects from a variety of sources and further develop this technology. In the process, they resolved many learning, logistical, and legal problems and moved this technology forward by an order of magnitude. Principal goals include: nationwide interoperability, network of repositories, linked servers, repository software programs, national and international standards, digital rights management, business and management models, evaluation and feedback, dissemination of results, and bilingual access to all Canadians, particularly learners with disabilities. The defined tasks were sub-divided into nine work packages, each with a lead institution as package manager.

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EduSource:

Canada's Learning Object Repository Network

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Background

The eduSource project is a collaborative venture among Canadian public and private sector partners to create the prototype for a working network of interoperable learning object (LO) repositories. The project uses Canada's broadband Internet network CA*Net4 as a development and application platform, with capacity to operate as well on the commercial Internet. The project is charged with the creation and development of the associated tools, systems, protocols and practices that support a distributed LO repository infrastructure. EduSource is committed to the implementation using international standards; it is bilingual (French and English); and it is accessible to all Canadians including those with physical disabilities.

Each of the partners and their associates are bringing considerable resources to the project. Collectively, the contributions of the partners from 2002 to 2004 amount to C\$5,330,000 of the total project value of C\$9,830,000. CANARIE, Canada's advanced Internet development organization (*CANARIE home page, 2003*) and Industry Canada are contributing up to \$4,700,000.

EduSource Organizational Structure

EduSource is a CANARIE project with six designated primary partners: Athabasca University (AU), the Netera Alliance (Netera), New Brunswick Distance Education Network/TeleEducation NB (NB DEN), the New Media Innovation Centre (NewMIC), Téléuniversité du Québec (TÉLUQ), and the University of Waterloo (UofW). The Netera Alliance serves as the lead contractor. The consortium includes several associates in the private and public sector representing companies and learning institutions from across Canada including the National Research Council (NRC). In addition, a team from the University of Alberta (UofA) is conducting a formal evaluation of the project (See Figure 1).

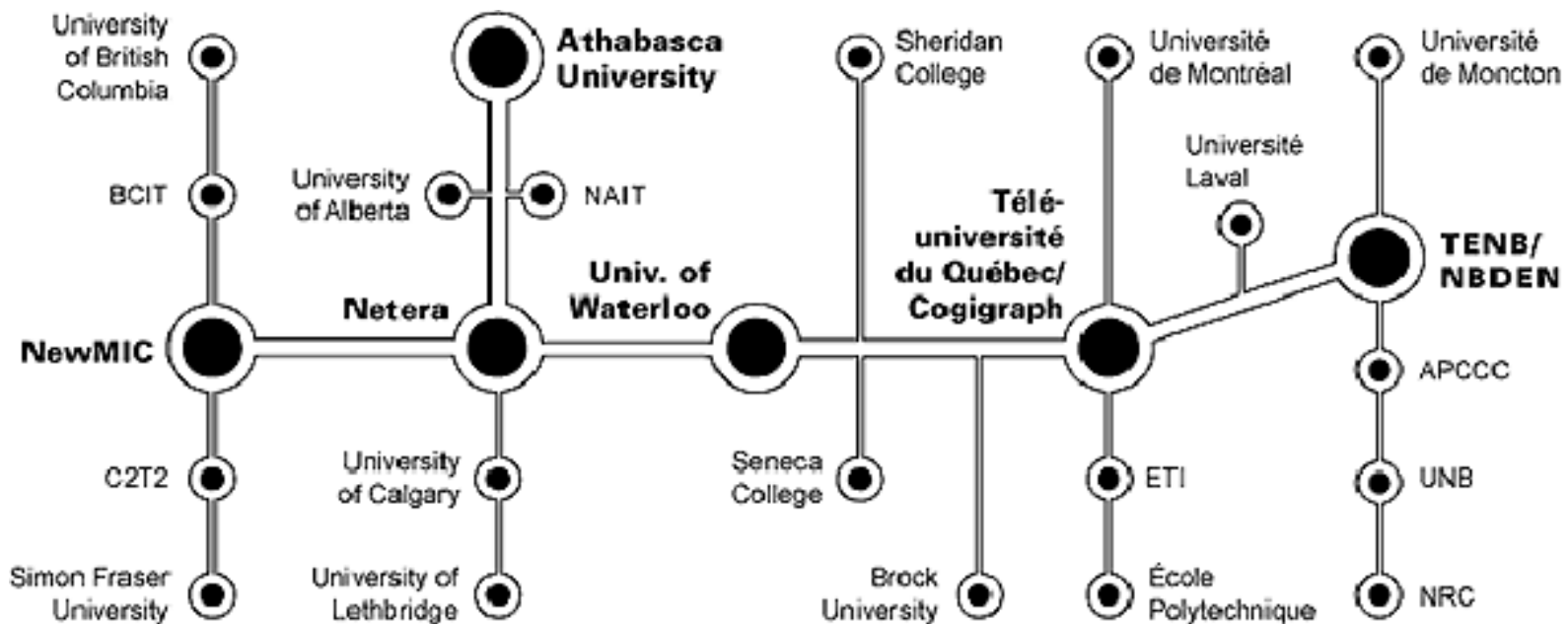


Figure 1. eduSource Organizational Structure

A principal objective of eduSource is the creation and deployment of a functional suite of tools capable of supporting the infrastructure for a national network of LO repositories. To accomplish this, eduSource is promoting a set of guidelines for the practical implementation of the IEEE LOM and SCORM standards for metadata, known as CanCore (*CanCore home page, 2003*). Research for the implementation is also being conducted in the areas of protocols, network engineering, hardware/software integration, software applications, service quality, security, and digital rights, while paying special attention to the requirements for quality pedagogy and accessibility for the physically challenged. The tools are being used to

investigate problems involved in the repurposing of educational materials as LOs, user support, professional development, peer review and community building.

To achieve these goals, the EduSource team identified ten specific objectives:

1. *Address and examine issues of interoperability by connecting a critical, mass of LOs housed in repositories across the country.*
2. *Play a leadership role in developing and promoting national and international standards.*
3. *Develop a blueprint for the rights management of LOs.*
4. *Link and integrate the development of repository software programs.*
5. *Create a physical test bed of servers linked together through CA*Net 4.*
6. *Build a bilingual pan-Canadian community of practice.*
7. *Examine new business and management models for object repositories.*
8. *Develop a communications plan for the dissemination of these results.*
9. *Accomplish these goals within the context of a comprehensive program of evaluation and feedback. And*
10. *Ensure that that these repositories will be accessible to all Canadians and particularly to those learners with disabilities. (eduSource Canada, no date)*

The EduSource project has been sub-divided into nine work packages, each with a lead institution as package manager (See Figure 2):

1. *Repository Content Development:* NBDEN and NewMIC
2. *Metadata Development:* AU
3. *Software Development:* Cogigraph (TÉLUQ)
4. *Hardware Integration:* Netera and NewMIC
5. *Digital Rights Management:* NRC

6. *Evaluation & Testing*: UofA
7. *Business and Management Models*: Netera
8. *Community Building*: UofW
9. *Project Management, Co-ordination and Communications*: Netera

Repository Content Development is led by NBDEN and NewMic. This group is charged with leading the development of LO repositories and LO metadata repositories. The team along with other partners is developing interfaces, templates and protocols necessary to connect existing and emergent learning object repositories (LORs) such as Alberta's CAREO (Campus Alberta Repository of Educational Objects) (*CAREO*, no date), New Brunswick's CanLOM/TeleCampus (*TeleCampus*, no date), Ontario's CLOE (Co-operative Learning Object Exchange) (*CLOE*, no date), the Athabasca University's Digital Library in a Box (ADLib) (*ADLIB*, 2003), and others across Canada and internationally, ensuring interoperability. Content of various types from the different project partners and associates is being repurposed, and adapted to form LOs. This includes the storage, indexing and segmentation of media types ranging from text to Java Applets; the development of archival standards for digital masters; and an evaluation of the effectiveness of the delivery of these objects through a variety of media including broadband, medium band, and wireless networks.

NBDEN is using the CanCore specification to build a next generation metadata directory, based on the TeleCampus engine, known as CanLOM. The University of Calgary (UofC) Learning Commons is also developing the CAREO metadata and LO repository using CanCore and is developing a sophisticated standalone tagging and content packaging tool known as ALOHA (*ALOHA*, 2003). Similarly, Athabasca University is building ADLIB as their university LO repository using the same standards and specifications thus ensuring interoperability.

Metadata Development is led by AU. Metadata is what separates repositories from the chaos of the World Wide Web. In this respect, the development of the CanCore metadata application profile is one of the most important deliverables of the entire project. EduSource is building on this success and furthering Canada's leadership in this area. The team is developing, extending and reinforcing CanCore, which is being translated/adapted into French. The most recent version is available at the CanCore web site (*CanCore home page*, 2003). EduSource is not merely conforming to internationally recognized metadata specifications. Its members are actively engaged in setting those standards. This project acts as a springboard for promoting the use of interoperable common vocabularies when implementing the IEEE LOM standard.

Software Development is crucial to the success of the entire project. TÉLUQ is leading the partners in the development of an integrated suite of software tools for the implementation and management of the LO metadata and LO repositories. These software tools form the foundation of the pan-Canadian repository network. This basic project infrastructure is built

on open source solutions to ensure the adoption and use of these tools across a full spectrum of Canadian and international educational organizations.

A crucial dimension of this work is the integration of existing software tools developed during the first phases of the E-Learning Program. These include eduSPLASH (*EduSPLASH*, 2002) for the creation of peer-to-peer networks of repositories; Explor@ II (*Explor@ 2*, 2003) for the management of repositories and the integration of resource into courses; ALOHA (*ALOHA*, 2003) for managing a LOR from the Learning Commons at the UofC, as well as ADLIB (*ADLIB*, 2003) and the MARC to LOM convertor (*MARC - LOM converter*, 2003) from Athabasca University for the metatagging of LOs. By making these tools and others work together and augmenting them with new applications and some strategic software 'bridges', eduSource is providing a comprehensive suite of repository building tools.

EduSource is experimenting in new areas of research and development such as the semantic web. "The Semantic Web is an extension of the current web in which information is given well-defined meaning, better enabling computers and people to work in cooperation." (Berners-Lee, Hendler, & Lassila, 2001). In other words, it makes it possible for information on the Web to be both syntactically and semantically understood by computer applications.

Most projects to date have focused on the formal description, tagging and distribution of educational objects. While this is an important first step, successful learning experiences are known to be dependent upon many other factors besides the availability of content. Recognizing this limitation, researchers have developed educational modeling languages (EML) that formally describe other critical components of the learning transaction. The IMS Learning Design specification (*IMS Learning design specification*, no date) based on EML from the Dutch Open University is expressed in formalized notation (using XML) to facilitate the searching and retrieval of LOs as well as the automated application of knowledge resources of various types on the semantic web not only by humans but also by autonomous agent software applications. AU, TÉLUQ, and UofW are working together on prototype implementations using IMS Learning Design. They are developing Open source tools for editing, packaging and playing Learning Design files.

Hardware Integration. As project managers responsible overall for project integration, Netera is working as the lead with NewMIC on this work package. The national eduSource test bed is designed to accommodate servers from various users and of various sizes, capacities and operating systems as well as exploring different architectures including both peer-to-peer and centralized server models. In all cases this package is informed by the principles of open systems and interoperability. The primary delivery mechanism for this network is the broadband Internet (CA*Net 4), but it is also investigating the delivery of LOs by other means. This includes the commercial Internet and wireless and satellite systems as well as the use of caching servers and other devices to enhance delivery and performance.

Digital Rights Management is being led by the NRC in Moncton, New Brunswick. This package began with a comprehensive survey of the literature in the fields of commerce and

information management, on the current state of DRM theory and technology, and an examination of emerging international standards such as the ODRL or Open Digital Rights Language (*Open digital rights language initiative*, 2003). Based on this research, a series of recommendations regarding DRM has been prepared and work is underway based on an XML DRM schema (See Downes & Babin, 2003).

Evaluation and Testing is being led by the University of Alberta, which has implemented a project evaluation strategy. Upon completion of the project, a summative evaluation will assess the impact of the project on practice within the participating organizations. It will also assess the project's success at meeting the initial project goals. Formative and summative data is being gathered through extensive interviews with key partners, associates, funders, surveys of end users and functional reviews of products created during the project.

Business and Management Models are being led by Netera, which is developing a business and management strategy. To this end a variety of funding models have been assessed. These include memberships, subscriptions, support and service contracts, licences and pay-per-use. This work is closely coupled with the Digital Rights Management Package. This work package also explores the sustainability of the LOR infrastructures among and within educational institutions.

Community Building is led by the University of Waterloo, which is developing networks of exemplary Canadian communities for the design, development, evaluation and exchange of LOs. COHERE (Canada's Collaboration for Online Higher Education and E-Research) is one such network in the post-secondary domain, where it demonstrates the use of online subject area communities to achieve efficiencies and promote cost-effectiveness (*COHERE*, no date). This community building is being extended into the K12 environment in collaboration with the Council of Ministers of Education Canada and provincial ministries of education.

Instructors at universities, colleges, schools, adult training centres, and the workplace are critical to the development of robust networks of communities. Project partners are developing exemplary proto-type networks of discipline-specific online communities to integrate local collaborations within their larger communities of use linking them to eduSource's pan-Canadian network of repositories.

Project Management, co-ordination and communication is the responsibility of the Netera Alliance which is providing central management functions, accounting and administration for the project as well as fulfilling the reporting requirements as stipulated by CANARIE.

Working Groups

There are three eduSource working groups: 1. the vision group; 2. the development group; and 3. the solutions & sustainability group. In addition, a management committee and a steering committee oversee and provide direction for the overall project. Figure 2 shows that

the development group is coordinating activities in work packages 1, 2, 3, 4 and 5 (on the left of the figure) while the solutions and sustainability group is acting to coordinate activities 6, 7, 8, and 9. The vision group has been created to identify overall orientations of the project and provide them to the other two groups as well as the management and steering committees. The three working groups meet regularly to help the steering committee orient and coordinate work in the nine work packages. The steering committee is responsible for taking the final decisions.

The vision group is responsible for continuously monitoring the norms and standards, elaborating the general orientation principles, defining use case requirements and functional architecture orientations, taking into account implementation specifications from the development group. It also ensures the preparation of proper user documentation, approves the evaluation process and suggests requirements on business models to the solutions & sustainability group.

The development group defines the system's architecture taking in account use case requirements and the functional architecture from the vision group. It selects the technologies, protocols and development tools, defines the implementation and deployment specifications, develops the software infrastructure for LORs, provides unitary testing and writes the developers' documentation.

The solutions and sustainability group organizes product evaluation and a deployment strategy to obtain useful feedback and recommendations from potential users. It develops partnership frameworks for content providers and specialized service providers, coordinates the integration of digital rights and other business tools and defines a framework for the sustainability of open source components, including both software and protocols. While keeping their own managing responsibilities, the five primary partners provide the human resources to achieve the eduSource deliverables (*EduSource software development and integration work package plan, Version 0.3, 2002*).

MANAGEMENT COMMITTEE

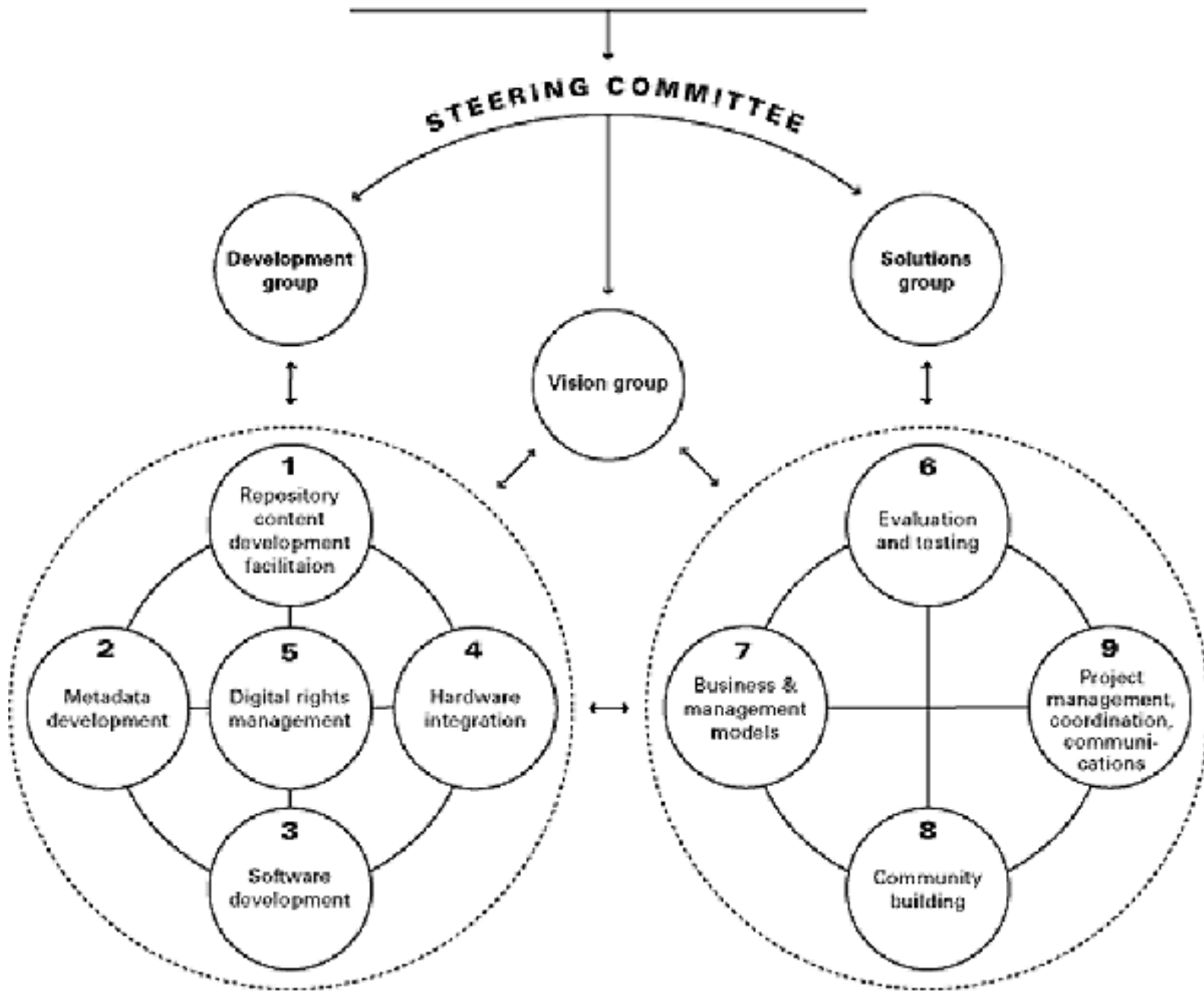


Figure 2. Working Groups

Canarie funded projects are dependent upon the participants paying for 50% of costs of the project. To ensure accountability for the project extensive book keeping, time sheet completion and rigorous accounting standards are required. To facilitate effective implementation of these accountability standards, the management committee, led by the lead Netera group, meets to ensure that fiscal planning and accounting is given a high priority.

Principles

The following design principles have been adopted in order to guide the development of the architecture for the creation of a distributed LO repository network(Downes et al., 2002).

1. *Network model* as opposed to a silo model with separate repositories fed by publishers often on the basis of separate licensing agreements that increases the cost and restricts the choice of learning materials for all users and especially for small users.
2. *Royalty free standards and protocols.* Wherever possible, the eduSource software system infrastructure is providing open source solutions to ensure the adoption and use of these tools across a full spectrum of Canadian and international educational organizations. However, this open source approach is limited to the distributed infrastructure. The applications and services built upon the infrastructure can be either open or commercial or both.
3. *Implementation and support for emerging specifications* such as the CanCore metadata application profile and related IMS specifications, whenever practical, including support for the use of defined and controlled vocabularies so as to provide semantic interoperability and functionality to end users searching for and retrieving LOs.
4. *Enable, don't require,* such that applications work using the widest variety of open standards, recommending and not dictating, aiming to achieve a consensus among core participants where possible and allowing dissent when it occurs without imposing conditions for use of the applications.
5. *Infrastructure layer and service layer.* The set of software tools comprising the infrastructure layer are to be distributed as royalty-free open source applications. Over and above the infrastructure layer, some components with increased functionality are being developed as free and open applications, while others include commercial and proprietary components.
6. *Distributed architecture.* EduSource infrastructure and services are being designed as a set of related components, each of which fulfills a specific function in the network as a whole. Any given software tool provided by eduSource may be replicated and offered as an independent service to provide robustness and ensure that no single service provider or software developer may exercise control over the network.
7. *Open marketplace.* EduSource supports the registration and indexing of various providers, this registration will be free and optional. EduSource will accommodate free, co-operative or shared, and commercial fee-based content distribution.
8. *Multiple metadata descriptions* of a given learning resource are possible, ensuring

that different users of the same learning resources can obtain, input, and access multiple descriptions of that material.

9. *EduSource is an implementation and extension of the semantic web*, accommodating sector-specific ontologies in the design to support the widest reach possible and reduce the duplication of effort between developers working in specific domains and educators working in the same domain.
10. *Open digital rights Management*. Where possible, the acquisition of rights and the exchange of funds is automated. Multiple digital rights models are being provided for free materials, cooperative sharing, and commercial offering on pay-per-view, or subscription-based, or other models. No single rights agency will govern all transactions. A given provider of learning materials may work with one of many brokers who sell to multiple purchasers, and a given patron may use one of many agents who conduct transactions with multiple vendors.

Edusource tools and services

The eduSource suite of applications consists of a set of inter-related components distributed over the Internet and capable of communicating with each other. This is accomplished by rejecting an integrated system architecture, and adopting a distributed model made up of distinct, stand-alone components that communicate over TCP/IP. Rather than one big application, the eduSource project allows for multiple components (even multiple similar components) as well as multiple LO metadata and object repositories. These repositories may be highly specialized (e. g., Egyptian Archaeology objects; a Blues music archive) or more generic (e. g., a large museum collection; a picture archive; a school board LO collection). This model is more in keeping with the distributed ideal of the World Wide Web.

The core components of the network are the LO repositories, which are hosted by the LO copyright holders and the LO metadata repositories, which may or may not be housed with the LO repository. Metadata repositories harvest metadata from LO repositories using applications like the OAI-MHP (Open Archives Initiative Metadata Harvesting Protocol) (Friesen, 2002) or directly from a Learning Content Management System (LCMS) or Learning Management System (LMS) using queries.

This core functionality is relatively simple and is already established in other domains, for example, in news syndication (Dumbill, 2000). Other implementations, including IEEE/P1484.1/D9> (Sonwalkar, 2002) employ a model whereby learning materials are treated like books in a library (or, in some other way, as "content" to be managed). Consequently, implementations of the architecture enable access to collections of this content, typically (but not always) stored on location. The process is therefore: acquire, index, and deploy.

In a network model, there is no need to manage collections of content. So, instead of working solely with formally structured LOs, the network works with "learning resources", or "learning opportunities". This includes, but is not limited to LOs. Journal articles, academic papers, seminars, instruments, games, actual in-person classes, or the instructors themselves. They can all be accessed using this model. EduSource enables this by tolerating the use of different schemas in LO metadata repositories.

Other features that are enabled by eduSource include component registry services by which organizations can provide indexing or registration assistance (see Friesen, 2002). These and other components stand alone and are not dependent on the other functions in the system to become operational. You implement them only if you need them. You can choose among a variety of different components that can reside inside or outside of your particular system. EduSource also supports multiple instances of third party metadata. This is metadata that is created by diverse users and housed on different servers, but describing the same LO (See Nilsson, Palmér, & Naeve, no date). For example, a library may create Dublin Core metadata; a university might use the IEEE LOM for its metadata; a private company might use its own proprietary metadata. These and other eduSource components such as that for Digital Rights Management, Middleware and Resource Management communicate with each other using a common communication language called the EduSource Communication Language (ECL).

EduSource Communication Language (ECL)

The ECL messaging protocol is based on a SOAP specification. It supports communications among a variety of communities, providing applications that map between different languages and ontologies. Using the eduSource suite of tools, user communities can render their repositories interoperable using the most up-to-date, internationally recognized specifications and standards (See Figure 3). This is accomplished in four different ways:

- § Communication protocol (HTTP, SOAP, XML-RPC, Peer-to-peer, etc.);
- § Communication language (OAI, ECL, eduSplash, etc.);
- § Metadata (IMS, CanCore, Dublin core); and
- § Ontologies made up of vocabularies for metadata.

Two middleware components support interoperability: 1) Semantic cobblestone, which enables new repositories to connect into the eduSource network by supporting mappings on the metadata and ontology layers (See Richards & Hatala, in press) and 2) a gateway that supports interoperability between the communication protocol and language layers. This ensures interoperability with other repository initiatives whether they be legacy using Z39.50 or new using the IEEE LOM.

The eduSource infrastructure supports 3 types of users:

- Individuals via peer-to-peer
- Communities with existing repositories via federated searches
- Organizations with restricted access via federated searches and metadata harvesting

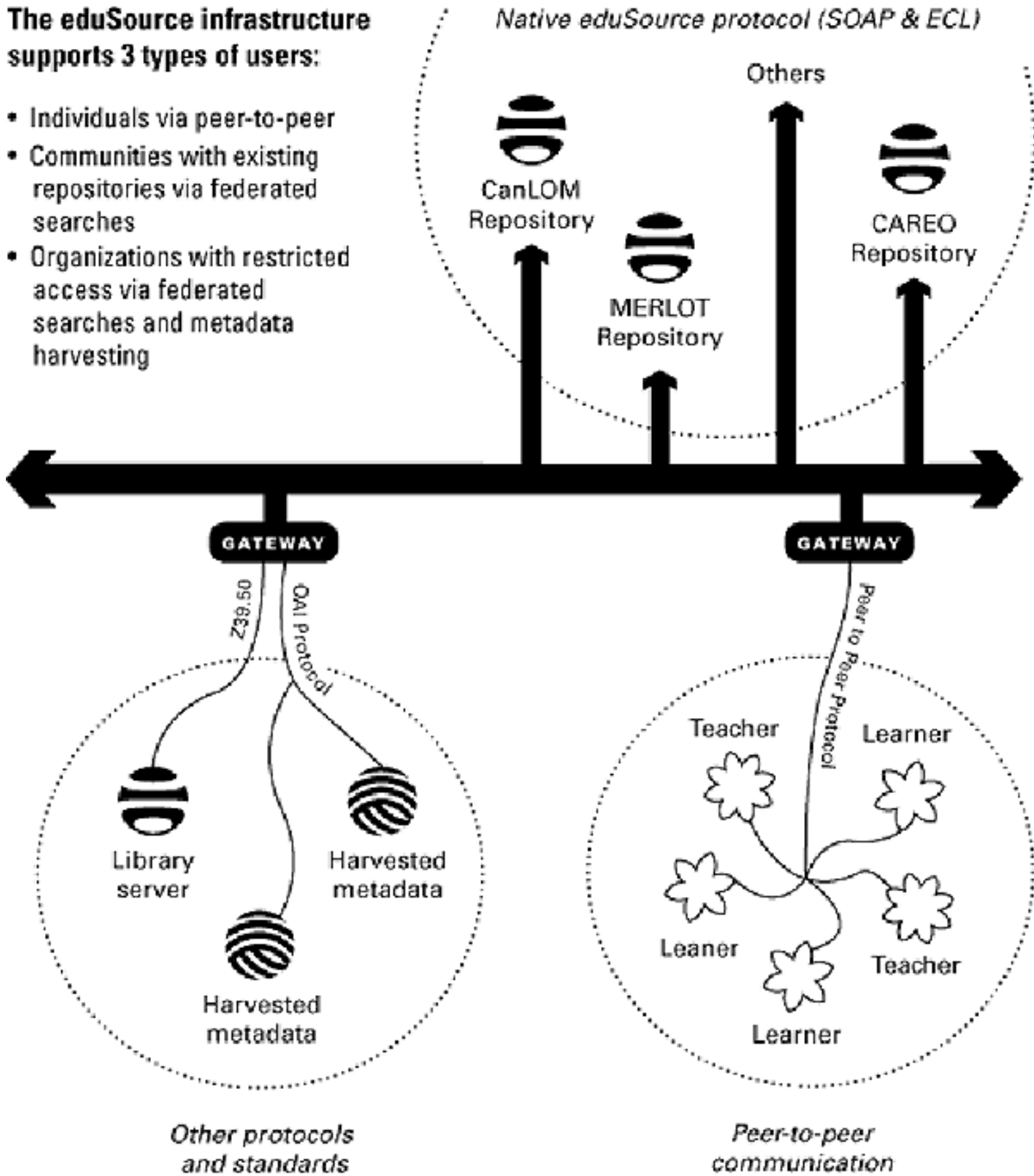


Figure 3. EduSource Communication Language

EduSource infrastructure

The Java programming language is being used for the implementation. J2SE (Java 2 Standard Edition) version 1.4.1 is required along with SOAP 1.2 with an attachment compliant engine to run it. AXIS (See *Concurrent Versions System*, 2002). The following features are presently under development and testing.

An application programming interface (API) for ECL is being specified at the gateway and at the client level. This forms the gateway framework for the suite of tools and communications among repositories. The first translators under construction are those between OAI and ECL and MARC and LOM. A Z39.50 translator is also being built along with other translators between different metadata profiles. And, to enlarge the communication capabilities of the existing systems, a generic ECL client API is being implemented, together with the specific code needed to link ECL with each of the CAREO, eduSplash, Athabasca University (ADLIB), and Explor@ systems. A Web services publishing registry, possibly using the UDDI standard, is being implemented to make the above services, and services from the other work packages, available and interoperable to internal and external LMS, LCMS or software agents.

EduSource middleware services consist of different components including a searched metadata viewer and resource launcher hook, which displays the result of searching metadata repositories using harvesting, federated or distributed search methods. It provides different views on the record set and it outputs the address and other information (for example DRM information) for a resource launcher to either facilitate or prevent launching. An IMS-LD graphical editor is being constructed that provides a user interface to create Learning Design components and produce the corresponding XML files according to the IMS-LD specification.

Metadata repositories services include bilingual (French/English) metadata indexing user guidelines. The levels are defined in the Cancore metadata application profile. Special guidelines addressing some difficult issues regarding catalog entries and unique identifiers have been analyzed and incorporated into the "good practice" recommendations. In addition, the guidelines present knowledge representation solutions linking metadata and the semantic web.

The IMS Digital Repositories Interoperability (DRI) specifications are being implemented for both federated searching and harvesting in multiple repositories, taking into account different communication protocols and different metadata application profiles, specifications and standards. Software components for peer-to-peer and client-server storage and deployment of metadata are also being developed, based on a network architecture of metadata repositories and resource repositories. A test bed network is being used to trial the components.

An open source content packaging tool is being constructed, based on the IMS and SCORM specifications. In conjunction with existing tools this application can enable the transfer of resources and their metadata for use by different eLearning systems or agents. This includes a robust version of the IMS-DRI submit/store specification enabling the movement of resources to and from repositories linked to network-accessible locations. One version of this IMS-DRI request/deliver specification is being implemented to transport, launch and deliver resources to and from LMSs. In addition, different resource aggregation methods are being studied, including those proposed by the EML-based IMS Learning Design specifications, to define an abstraction level for elearning system building.

A Digital Rights Management (DRM) software component is being implemented enabling any eLearning system or agent to display any type of provider-defined DRM model. A user searching for LOs or other resources will be informed of the conditions and methods for accessing them. Another software component enables a user-agent to make requests to provider-agents, allowing them to access the resources if they possess the required permissions.

Figure 4 offers a general functional view of the suite of eduSource software tools and services. It presents three sets of components based on an open network approach. On the right side, there are two classes of repositories, one for metadata and the other for digitized resources (assets). In the Centre, five groups of services compose the infrastructure of the eduSource suite of tools. On the left side are existing or future e-learning systems, Learning Management Systems (LMS), Learning Content Management Systems (LCMS), agents or tools that can contribute to build and/or use repositories.

Each *Metadata Repository* houses a set of metadata files describing educational resources sometimes referred to as learning objects. Here we use a very broad definition of a LO as in the IEEE LOM document and the IMS Learning Design specification. This definition is also in line with the taxonomy of resources provided by the MISA instructional engineering method (*MISA learning systems design tool*, 2003). It includes the following categories of resources:

- Documents and educational materials (multimedia, Web pages, texts, software, data records, etc.) that hold information and knowledge;
- Tools and applications that support the processing of information and knowledge;
- Services provided by people such as subject matter experts, trainers, technical assistants, managers;
- Events (or learning opportunities) such as courses, seminars, learning activities, conferences, and discussion group meetings;

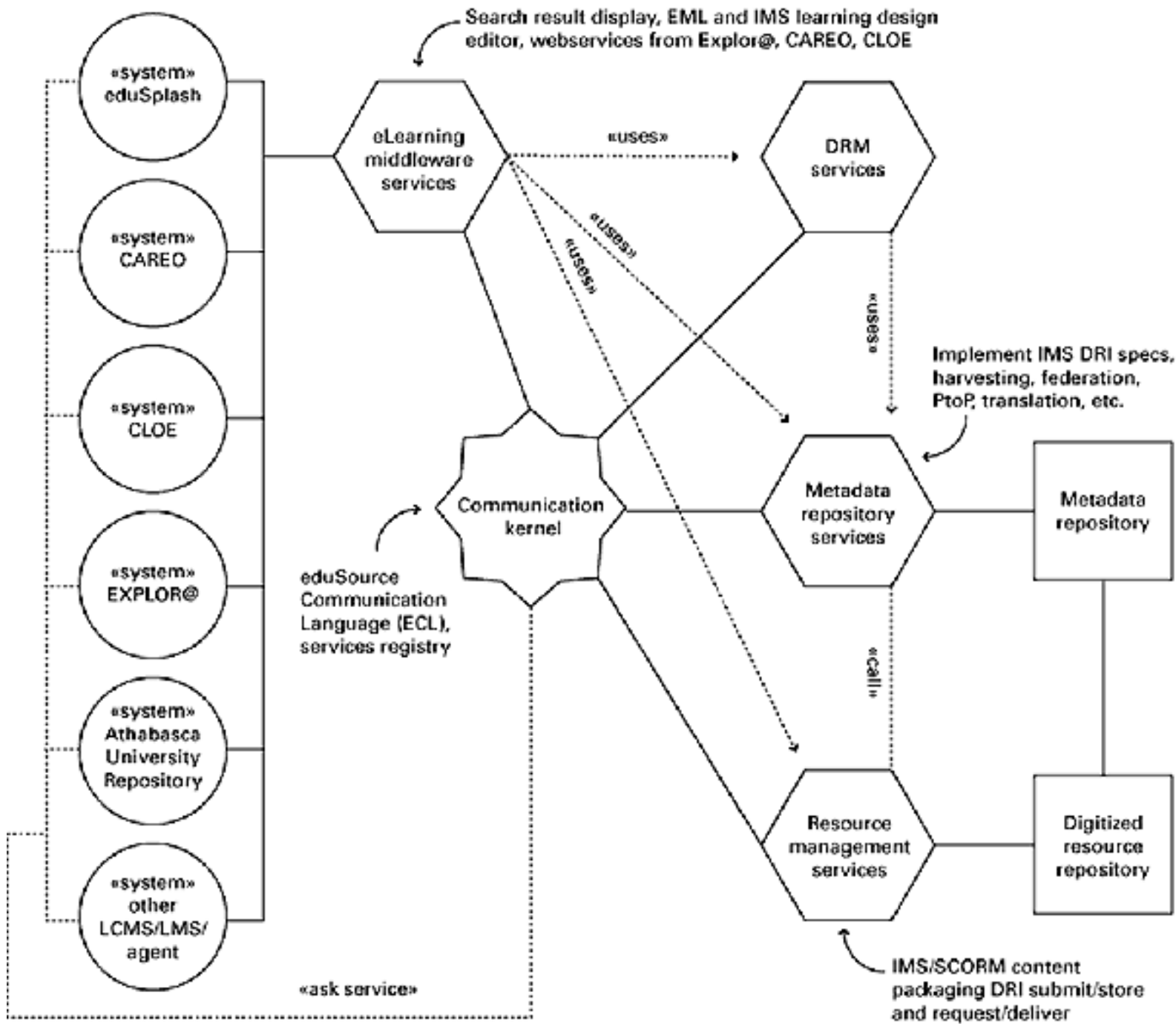


Figure 4. EduSource general functional diagram

Each *Digital Resource Repository* holds a set of digitized resources. The core of the system lies in the **five main software packages** at the centre. They hold the suite of software components that are being developed by the eduSource team. These services are all being referenced in one or more *eduSource Service Registries* available from the Web. Any service can be called upon by any e-Learning System or agent.

- The Communication Kernel includes the ECL, which (as previously mentioned) is a meta-protocol offered to all eduSource users that enables interactions between tools, services and communication protocols, in particular OAI and Z39.50. It also contains the eduSource Services Registry (ESR) that references all the components

in the infrastructure from which an eduSource user can select the services that he or she wishes to use.

- The E-Learning Middleware Services component groups all the interactions to functionalities in elearning systems or agents whose providers agree to be referenced in eduSource. It includes services giving access to functionalities supported by Explor@, eduSplash, CAREO, ADLib and other systems external to the eduSource infrastructure. It includes one or more tools to display metadata and the associated resources resulting from searches implemented in the metadata repository services. It also includes a Graphic Learning Design Editor producing EML/IMS-LD code that can be passed on to a content packager producing content to be read by any compliant elearning system.
- Metadata Repository Services is a package that implements the most essential functionalities to fully exploit a set of (partly redundant) metadata repositories. In particular, this package is implementing some of the IMS DRI specifications for searching, harvesting, and federating such as gather/expose and search/expose, as well as peer-to-peer distributed search. It also includes translation services between metadata specifications or standards such as DC, IEEE LOM, and MARC, and also between natural languages, including French-English translations of metadata.
- Resource Management Services is a package that takes care of operations needed to launch, aggregate, package, or transport the actual resources required by any other service or system. It is implementing an IMS-SCORM content packaging service, and DRI submit/store and request/deliver functions.
- Digital Rights Management Services is a package grouping all the components for the management of interactions on digital rights and intellectual property between providers and users of resources and services. It houses a *Provider Broker* to enable a LO provider to select a particular DRM model and produce the associated DRM metadata. This service contains a *Purchaser Broker* providing user identification, payment transactions and authorization to deliver the LO. It provides a simple encryption mechanism to secure transactions and adapt the LOM metadata for digital rights management.

The links between these components show a variety of attributes maximizing the flexibility of interactions between existing systems and new components. There is a many to many correspondence between metadata repositories and the LO repositories. This is a way to implement a full network approach as opposed to a silo approach. It enables (but does not require) a metadata repository to reference resources in more than one resource repository and, conversely, a resource repository to be referenced by more than one metadata repository. At the individual LOM level, it supports multiple metadata descriptions of the same resource.

There is no central piece in the system and components can be duplicated for redundancy

and robustness. Registries can be one or many. And services can be offered in more than one version. The architecture of the eduSource system embeds these principles right from the start, providing for future evolution.

Community Building

As previously noted, eduSource is also charged with building the community of LO users. After examining different organizations, the UofW work package leaders chose MERLOT (*CAREO*, no date) as a model for community building. Using the MERLOT concept and starting in Ontario, the team created a consortium of post-secondary institutions called CLOE (Co-operative Learning Object Exchange). A vibrant CLOE community has been established with representatives from each CLOE partner institution. They attend quarterly face-to-face meetings and participate in monthly teleconferences. All CLOE partners are promoting LO repositories on their campuses. For example, CLOE advertisements are posted in appropriate areas at all CLOE partner institutions. As well, many talks have been given at partner institutions regarding LO repositories. CLOE partners have established various initiatives within their institutions. For example, Queens has established CLOE@QUEENS as a Community of Practice regarding LOs and repositories (*CLOE@QUEENS*, no date).

Although based on MERLOT, CLOE has made some significant alterations to the original MERLOT concept. For example, MERLOT does not host LOs but rather is a 'referatory' to the LO which continues to reside on the author's site. The LOs and the relevant metadata are both actually hosted at the CLOE web site. This gives CLOE much more control over versions and control over ensuring that materials does not get deleted or changed significantly. It also allows producers and managers to quantify the number and, type of LOs as well as the context for which each object is being downloaded.

MERLOT also has an established peer review process (having completed more than 1000 reviews by the Fall of 2003). The CLOE team is using the MERLOT peer review process as a guideline, and is examining the entire system with a view to making the peer review robust and auditable so as it can be used to enhance an author's professional portfolio for purposes of promotion and tenure (see Kestner, in press). In addition, MERLOT has no way of tracking what LOs have been reused. CLOE on the other hand produces reports each semester that detail all the reuses of LOs in CLOE. This information, coupled with the peer review, can often be valuable in enhancing an author's professional portfolio.

The original community building focus has been on Ontario universities (through CLOE) and internationally through MERLOT. The experience of getting the CLOE group 'on track' is seen as a necessary 'first step' before attempting any significant national community building. The chief effort so far, has been to host the MERLOT International conference in Vancouver (*MERLOT International Conference*, 2003). This conference brought Canadians together with Americans in a forum to discuss issues associated with LOs and repositories. This major international conference has been supplemented by an ongoing series of workshops in cities across Canada and international presentations at a variety of different

venues.

The different eduSource partners continue to disseminate their vision and results of their research among the eduSource community and a variety of stakeholder communities. These include other universities, community colleges, school boards and departments of education, other government departments, private companies and interested organizations. International connections have been established with ARIADNE in Europe (*ARIADNE*, 2002), the Education Network of Australia (*EdNA Online*, 2003), the IMS in the USA (*IMS*, 2003), and other groups in Japan, Korea, Taiwan, Singapore and China.

The eduSource Canada website is also being used for community building (*eduSource Canada*, no date). It has been live since December 2003. It changes and develops along with the project to reflect the needs of emerging user communities and internal project evaluative feedback. Added components include an internal web-based document sharing system, a digital rights clearing house component and a detailed presentation and news information section.

The eduSource site is bilingual (French and English) and all relevant documents are posted in both official languages.

Summary

This eduSource project represents a constructive collaboration among a diverse group of participants who have accepted common basic principles for the design and construction of an open network of learning repositories. The initial goals have been outlined along with descriptions of the actual work in progress including descriptions of the organizational structure, the workgroups, work packages, and the tools and services to be integrated into the eduSource suite of tools. This project aims to provide leadership in Canada and internationally in the development of interoperable repositories using the developing semantic web.

Abbreviations and Acronyms

| | |
|----------|---|
| ADLIB | Athabasca University Digital Library in a box |
| API | Application Program Interface |
| AU | Athabasca University |
| AXIS | a specific implementation of SOAP |
| CANARIE | Canada's broadband Internet organization |
| CANet 4* | Canada's broadband network |
| CLOE | Co-operative Learning Object Exchange |

| | |
|---------|--|
| CVS | Concurrent Versions System |
| DRI | Digital Repositories Interoperability (from IMS) |
| DRM | Digital Rights Management |
| ECL | eduSource Communication Language |
| EML | Educational Modeling Language |
| HTTP | HyperText Transfer Protocol |
| IEEE | Institute of Electrical and Electronic Engineers |
| IMS | Instructional Management System |
| J2SE | Java 2 Standard Edition |
| LCMS | Learning Content Management System |
| LMS | Learning Management System |
| LD | Learning Design |
| LO | Learning object |
| LOM | LO Metadata |
| LOR | LO Repository |
| MERLOT | Multimedia Educational Resource for Learning and Online Teaching |
| NBDEN | New Brunswick Distance Education Network Inc. (TeleEducation NB) |
| NewMIC | New Media Information Centre of British Columbia |
| NRC | National Research Council of Canada |
| OAI | Open Archive Initiative |
| OAI-MHP | OAI Metadata Harvesting Protocol |
| ODRL | Open Digital Rights Language |
| SCORM | Shareable Courseware Object Reference Model |
| SOAP | Simple Object Access Protocol |
| TÉLUQ | Téléuniversité du Québec |
| UDDI | Universal Description, Discovery, and Integration |
| UML | Unified Modeling Language |
| UofA | University of Alberta |
| UofC | University of Calgary |
| UofW | University of Waterloo |
| XML | Extensible Markup Language |
| XML-RPC | XML Remote Procedure Calls |

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