SeLeNe - Self E-Learning Networks
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WP2 Deliverable 2.2

Self E-Learning Networks — Functionality, User Requirements and Exploitation Scenarios

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Abstract

This deliverable addresses the functionality, user requirements and exploitation scenarios of the SeLeNe project. We begin by introducing the aims of SeLeNe and discussing users' expectations of e-learning systems. We then describe the main functionality of SeLeNe. Next, we compare SeLeNe with traditional learning management systems, intelligent tutoring systems, and other related research projects, highlighting in particular SeLeNe's novel features. We conclude the report with a discussion of where SeLeNe fits into the broader e-learning spectrum, developing three exploitation scenarios and positioning SeLeNe with respect to Salmon's four 'Planet' scenarios.

This document reflects discussions that have been held with colleagues at the Institute of Education regarding learners' and instructors' expectations of e-Learning environments, and we gratefully acknowledge their input. We also acknowledge the many fruitful discussions with and significant input from our partners on the SeLeNe project at FORTH (Crete), LRI (Paris) and the University of Cyprus.

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The SeLeNe Project

Life-long learning and the knowledge economy have brought about the need to support a broad and diverse community of learners throughout their lifetimes. These learners are geographically distributed and highly heterogeneous in their educational backgrounds and learning needs. The number of learning resources available on the Web is continuously increasing, thus indicating the Web's enormous potential as a significant resource of educational material both for learners and instructors.

The SeLeNe Project aims to elaborate new educational metaphors and tools in order to facilitate the formation of learning communities that require world-wide discovery and assimilation of knowledge. To realize this vision, SeLeNe is relying on semantic metadata describing educational material. SeLeNe offers advanced services for the discovery, sharing, and collaborative creation of learning resources, facilitating a syndicated and personalised access to such resources. These resources may be seen as the modern equivalent of textbooks, comprising rich composition structures, 'how to read' prerequisite paths, subject indices, and detailed learning objectives.

The SeLeNe Project (IST-2001-39045) is a one-year Accompanying Measure funded by EU FP5, running from 1st November 2002 to 31st October 2003. The project falls into action line V.1.9 CPA9 of the IST 2002 Work Programme, and is contributing to the objectives of Information and Knowledge Grids by allowing access to widespread information and knowledge, with e-Learning as the test-bed application. The project is conducting a feasibility study of using Semantic Web technology for syndicating knowledge-intensive resources (such as learning objects) and for creating personalized views over such a Knowledge Grid.

Executive Summary

This deliverable (2.2) is part of the SeLeNe Workpackage 2. Workpackage 2 has two main objectives:

- To study existing metadata schemas for describing educational material.
- To identify instructors' and learners' expectations of e-learning environments, and define the functional requirements of SeLeNe.

Self e-learning networks rely heavily on machine processable and semantically intensive metadata describing the meaning, usage, accessibility, quality, and validity of available educational resources. This workpackage is studying the most commonly used types of learning objects and the corresponding description granularity which the metadata must support in order to enable their syndication and personalisation. Identifying the appropriate description granularity of educational resources requires a clear understanding of the semantics of existing educational metadata schemas, as well as their relationship to domain/task-specific taxonomies dynamically constructed by the SeLeNe users for their own learning purposes. Deliverable 2.1 is reporting on these issues.

Workpackage 2 is also studying learners' and instructors' expectations of Web-based e-learning environments. This has been combined with an analysis of state-of-the-art Learning Management Systems in order to ascertain the functional requirements of SeLeNe, both from the learner's and the instructor's perspective. Deliverable 2.2 is reporting on these issues.

The scope of this Deliverable 2.2 is to address the functionality, user requirements and exploitation scenarios of the SeLeNe project. We begin by introducing the aims of SeLeNe and discussing users' expectations of e-learning systems. We then describe the main functionality of SeLeNe. Next, we compare SeLeNe with traditional learning management systems, intelligent tutoring systems, and other related research projects, highlighting in particular SeLeNe's novel features. We conclude the report with a discussion of where SeLeNe fits into the broader e-learning spectrum, developing three exploitation scenarios and positioning SeLeNe with respect to Salmon's four 'Planet' scenarios.

Revision Information

Revision Date	Version	Changes
January 7, 2003	1.0	First Draft Proposal
May 14, 2003	1.1	Second Draft Proposal
June 3, 2003	2.0	First Full Version (main change: SeLeNe will not access LO content)
August 5, 2003	2.1	Second, Final Version

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1 Aims of the Project

Life-long learning and the knowledge economy have brought about the need to support a broad and diverse community of learners throughout their lifetimes. These learners are geographically distributed and highly heterogeneous in their educational backgrounds and learning needs. The number of learning resources available on the Web is continuously increasing, thus indicating the Web's enormous potential as a significant resource of educational material both for learners and instructors.

However, there is an urgent need for tools that match learners' needs with the content of the educational resources available on the Web. There has recently been an emergence of several metadata standards for educational material. But the vast majority of educational resources available on the Web do not provide metadata expressed in any of these standards, and keyword-based search using current Web search technology is generally not fine-grained enough to satisfy the specific educational needs of particular groups of learners, or individual 'self-learners'. Thus, semantic metadata describing educational resources needs to be exploited. In particular, users need to be able to query such metadata in order to locate resources appropriate for their specific learning or teaching needs. Users also need to able to define personalised views over this potentially large number of heterogeneous resources.

The SeLeNe Project aims to elaborate new educational metaphors and tools in order to facilitate the formation of learning communities that require world-wide discovery and assimilation of knowledge. To realize this vision, SeLeNe is relying on semantic metadata describing educational material. SeLeNe offers advanced services for the discovery, sharing, and collaborative creation of learning objects, facilitating a syndicated and personalised access to such resources. These resources may be seen as the modern equivalent of textbooks, comprising rich composition structures, 'how to read' prerequisite paths, subject indices, and detailed learning objectives.

In Stratakis et al. (2003) several possible definitions of a *learning object* are explored, and a working definition to be used in the context of the SeLeNe project is proposed:

Learning objects are electronic, sharable chunks of reusable learning content, available on the Web.

SeLeNe will support specific communities of authors and learners, who are providing and consuming specific learning objects. Thus, in the context of this project, we assume that the learning objects described by a self e-learning network (SeLeNe) are those web-based chunks of learning content that have been explicitly made available to the SeLeNe by its users.

As discussed in Allwinkle et al. (2002), a learning community can be seen both as an organisational context and as a pedagogical method. Organisationally, learning communities can occur in an educational institution, in the work-place, in a geographical region, on the Web. Pedagogically, the aim of learning communities is to 'liberate' the learning process from hitherto formal education systems and help the learner to achieve the ability of self-learning, a crucial characteristic in an environment where lifelong learning is

required. Learners organise themselves into communities according to their own criteria, such as needs, interests, preferences etc. These self-organized communities may require the external support of instructors and experts, who need to be knowledgeable in guidance of and interaction with learners as well as in the content of the topic at hand.

2 Users' Expectations of e-Learning Systems

There seems to be much anecdotal mention of user expectations for e-learning systems (e.g. "our system exceeds users' expectations", "most e-learning systems fail to meet user expectations", "e-learning gives low learner satisfaction") but little in the way of published user requirement studies. Many people offering guidelines about how to develop e-learning systems offer little or no evidence to back up their claims that "this is how to satisfy users of an e-learning system". Completion rates for purely electronic courses are generally low, with 15-20% being a respectable figure. This would seem to suggest that such systems often fail to meet user requirements somewhere along the way.

Many of the suggestions about how to satisfy users of an e-learning system relate to the final presentation of learning material, and have a lot in common with principles of good web-design in general. These include recommendations such as:

- Keep the number of 'clicks' needed for navigation to a minimum.
- Have versions of content that are suitable for users with any connection speed.
- Keep scrolling to a minimum.
- Have a consistent user interface, and include a 'help' button.

However, issues of the final presentation of material really fall outside of the scope of SeLeNe — 'good' learning objects will conform to good presentation principles, but the SeLeNe project itself is not about the design of learning objects.

There are some issues that apply to all teaching and learning which are not very well addressed by current e-learning systems:

- Learners have different learning styles — different people build, process and store knowledge in different ways. This means that different people will relate to a particular learning resource in different ways. Human instructors can learn which style of presentation suits which learner and adjust their mode of presentation accordingly.

  Current e-learning systems do not really allow for this at all, and will present the same sequence of learning modules to every user of the system. Some systems do allow course designers to specify which materials should be presented to which users at which time, but even where such facilities exist they are rarely used. This is due to the time, effort and expense involved in producing multiple pieces of content presenting the same material in different ways, and then setting up the system to deliver it only to the right students.

A solution would be to select materials for users with different learning styles automatically, thus removing the burden from the course designer — if learning objects are marked-up with sufficiently detailed pedagogic metadata (e.g. "this learning object is particularly useful for helping visual learners grasp such-and-such a concept"), and learners have profiles that match up with this (e.g. "this person learns things best when they are presented visually"), then a search utility over a learning object repository should be able to match users' learning styles as well as the content they require.

- Learners have different backgrounds and previous experience, so different learners may need to focus on different material to achieve the same eventual learning objective. For example, one learner might need to gain knowledge of statistical techniques, another medical practice, and another recent political history, for each of them to reach the objective of "being able to critically assess problems facing the health service today".

There are also issues specific to searching for electronic educational resources:

- Learners at different levels of attainment or following different curricula may use the same search terms, but are looking for very different material. For example, a secondary school pupil searching for 'atomic structure' will require different information from a Chemistry Masters student searching for the same thing. This problem arises less in a traditional learning environment because the library (and hence textbooks) available to students at different levels are different. In our example, each student would visit their respective libraries, look for a science/chemistry textbook, check for 'atomic structure' in the index and find material at the required level. With a distributed electronic repository of learning objects, materials at all levels would be returned by a search for 'atomic structure'.

- Even learners at the same level have different objectives in seeking learning material, e.g. "I want to cram enough to be able to pass an exam" as opposed to "I really want to deepen my understanding of this topic".

In terms of user expectations, all of these issues can be summarised as "I want the system to give me exactly what I need, when I need it, even if I don't know exactly what I need myself". This is a tall order, but our aim is that SeLeNe will begin to address some of these issues through the creation of user profiles to aid personalisation of search and retrieval through a space of learning objects and their associated metadata.

3 SeLeNe Functionality

We envisage many self e-learning networks (SeLeNe's) running world-wide, created by and serving different communities of users. We expect such SeLeNe's to be used for both *assisted* and *unassisted* learning, i.e. both by learners who access learning objects recommended by

their instructors, and by learners who find relevant learning objects on their own[1]. We also envisage the possibility that a learner may initially be assisted by an instructor and over time the learner will become more knowledgeable and require less assistance (see Peterson (2003)).

New nodes will be able to join a SeLeNe network by contacting a known node of the particular SeLeNe they want to join. There will be a *user registration service* for users to register with a SeLeNe via one of its nodes. The users of a SeLeNe will include authors, publishers or, more generally, providers of learning objects, instructors, and learners. Thus, the users of a SeLeNe will both *produce* and *consume* learning objects. When they register, users will be able to supply information about themselves and their educational objectives in using this SeLeNe. This information will be stored in their *personal profile*.

A SeLeNe will provide publishers with facilities via which they can make available to other users of the SeLeNe access to their learning objects (LOs) (via the LO's URI) and to metadata describing these LOs. We call this process *registering a LO with a SeLeNe*.

It should be emphasised that a SeLeNe is *not* a Learning Management System (LMS). Authors maintain control of the content they create and are free to use any tools they wish to create their LO content, including a LMS. We call such LOs created externally to SeLeNe *atomic LOs*.

The numbers and diversity of the potential LOs, and the physical distribution of the potential users of a SeLeNe, means that its metadata repository may need to be distributed. This metadata repository describes the LOs and users currently registered with the SeLeNe.

The SeLeNe will provide users with browsing and searching facilities over the LO metadata which return results tailored towards users' individual goals and preferences. The SeLeNe will also provide users with facilities for defining *views* over the LO metadata. Such views will be automatically generated from information within their personal profile, and in particular that part of the profile that specifies the user's learning objectives and current level of knowledge. Views may be virtual or materialised.

A SeLeNe will give LO providers facilities by which they can replace the metadata describing a previously registered LO by a new description of this LO. Such an update may, for example, reflect a change in the LO's content or simply an evolution of its description. The latter may arise, for example, if the provider later discovers an error in the description, or wishes to remove some parts of it, or wishes to add more information about the LO. Another possible scenario is that a metadata extraction tool may automatically provide some more information about the LO later on.

Any user of a LO may wish to be notified of changes made to the LO's description. SeLeNe will provide such automatic change detection and change notification facilities by comparing the new and old description of the LO (we do not envisage SeLeNe being able to 'look inside' atomic LOs to look at changes to actual content). More generally, SeLeNe will support personalised notification services depending on users' profiles.

Users will be able to register with a SeLeNe new *composite LOs*. These are LOs

[1]We note that 'assisted learning' is analogous to the 'instructed access' scenario of Löser, Grune and Hoffman (2002).

which have been created as assemblies of existing LOs registered with the SeLeNe, which themselves may in turn be either atomic or composite. An example of a composite LO is a course LO which has been created by assembling a number of module LOs. The SeLeNe will be able to automatically derive the taxonomical description of a composite LO from the taxonomical description of its constituent LOs.

Users will also be able to author trails of LOs, where by *trail* we mean a sequence of LOs that reflects a possible order of consumption of LOs, which is appropriate for some specific learning needs and goals. An example would be an instructor recommending a trail appropriate for a specific learner or group of learners.

In summary, SeLeNe will support the following:

(1) A user registering a new atomic or composite LO.

(2) A user authoring a trail of LOs.

(3) A user searching and retrieving LOs, and maintaining a set of personal trails.

(4) A user searching and retrieving LOs via a personalised view of the LO descriptions.

(5) A group of users collaborating in searching and retrieving LOs, and maintaining a shared set of trails.

(6) Personalised event detection and notification services, both explicitly specified and derived from information within personal profiles.

Provision of the above functionality will require the following, amongst other things:

- facilities for registering new atomic and composite LOs;
- techniques for reconciliation and integration of metadata describing heterogeneous distributed LOs;
- definition of personalised views over the LO information space — by *LO information space* we mean the LO descriptions and the schemas that these conform to;
- browsing and querying facilities over the LO information space, which return results tailored towards users' individual goals and preferences;
- creation and maintenance of individual and group trails;
- detection and notification of changes to LO descriptions.

We address these points in more detail in Sections 3.1 to 3.4 below. The figure below illustrates the high-level architecture of SeLeNe and its main components. Deliverables 3 and 5 of the project will be elaborating on the individual services and on the architectural choices for SeLeNe, respectively.

3.1 Registering Learning Objects

Learning objects will provide the learning content of a self e-learning network. Users will be able to register with a SeLeNe both *atomic LOs* and *composite LOs*.

Atomic LOs are independent of any other LOs. They provide the smallest fragments of LOs from which other, composite, LOs can be constructed. Depending on the application area and preferences of the author, such fragments might correspond to an individual slide used during a conventional lecture, or to all of the material for such a lecture.

To participate in a SeLeNe, atomic LOs need to be registered with the SeLeNe and be described using appropriate metadata. At a minimum, we expect that the metadata for a LO will be represented using the RDF/S binding of IEEE LOM.

Descriptions using other appropriate domain or task-specific taxonomies may also be made available by the LO's provider, possibly expressed in a variety of natural languages. Additional forms of metadata may also be useful: these should conform with emerging standards and a SeLeNe should be able to exploit them through extensibility mechanisms.

Composite LOs are characterised by being assembled from a number of other LOs, which themselves may in turn be either atomic or composite. SeLeNe will be able to automatically derive the taxonomical description of a composite LO given the taxonomical descriptions of its constituent LOs. The provider of the composite LO will be able to manually extend this part of the LO's description with further information conforming to the IEEE LOM. We refer the reader to Rigaux and Spyratos (2003) for a deeper discussion of atomic and composite LOs, including mechanisms for querying such LOs.

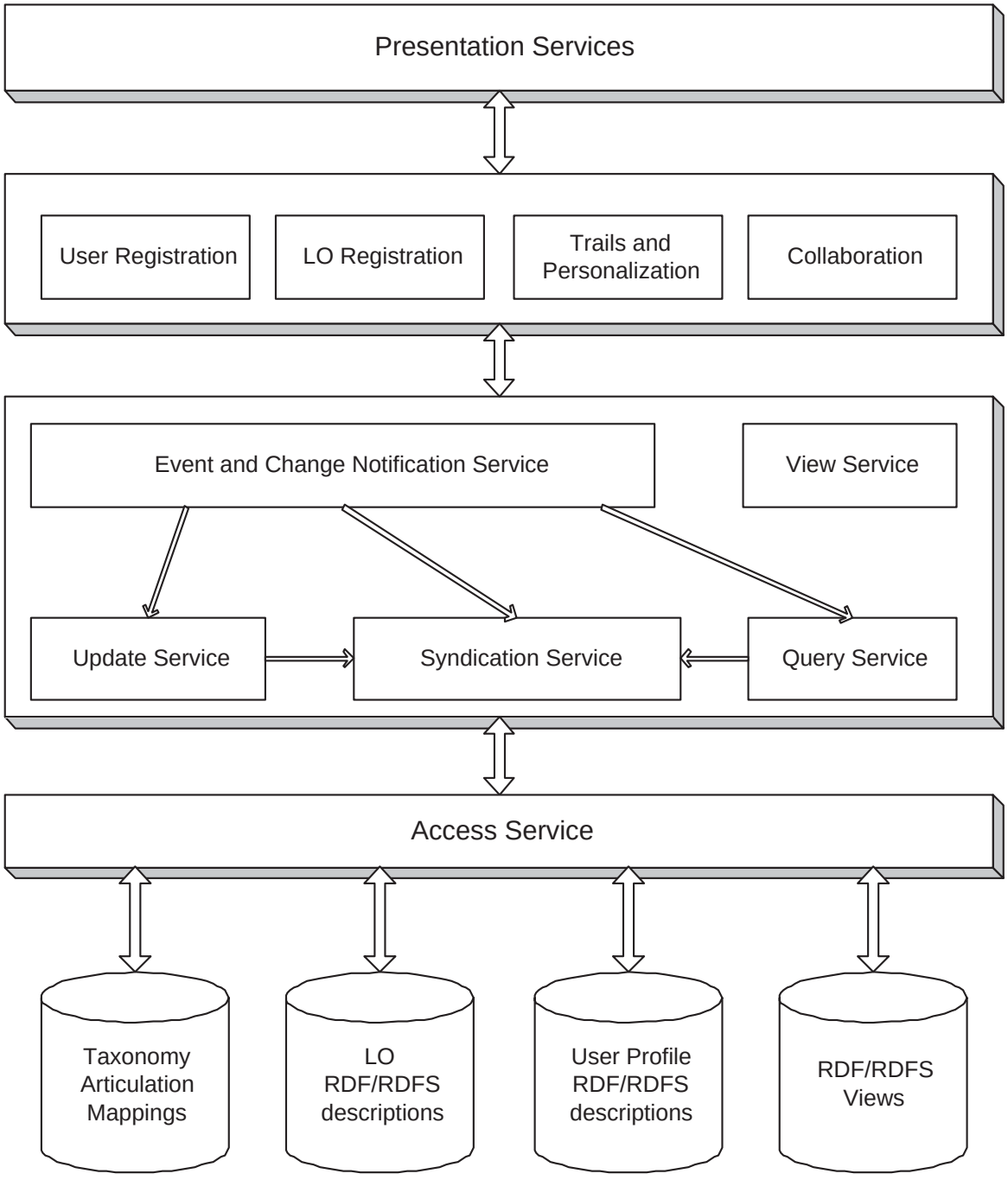
In addition to providing facilities for new LOs to be registered, there are also facilities allowing the current description of a LO to be replaced by a new description. There are also facilities for a provider to remove one of their previously registered LOs, and hence its description, from the SeLeNe provided this LO is not referenced by any other description. Each of these events (registration, update, removal) will be automatically notifiable by the SeLeNe to users who have registered with this notification service, as will other events such as users accessing particular LOs.

A user of a LO may wish to be notified of specific kinds of changes that occur to a LO's description. The SeLeNe will be able to provide such automatic change detection and change notification facilities by comparing the new and old descriptions (we stress that we will not be accessing the LO content itself, at least in the context of the present project).

If an author has constructed a composite LO, O, from some existing LOs $O_1, \ldots, O_n$, the author can request to be notified of changes to the descriptions of $O_1, \ldots, O_n$. The SeLeNe will automatically propagate changes in the taxonomical description of any O_i to the taxonomical description of O.

When providers register LOs with a SeLeNe, they should be allowed to define access and usage rights of both the LO and its description to other categories of users. They should also be able to define the price of access, if any, for each category of user and for each type of access. Enforcing this functionality lies outside the scope of the present SeLeNe project, but see Stratakis et al. (2003) for a discussion of digital rights.

Finally, it is important that SeLeNe provides facilities supporting the *evolution* of LO



SeLeNe High-Level Architecture

descriptions. This will be needed, for example, in order to allow providers to augment the description of a LO over time, even if the LO content itself is not changed. Also, SeLeNe should allow for evolution of the LO metadata standards and the domain/task-specific taxonomies to which the LO descriptions conform.

In summary, we envisage change occurring at all of the following three levels of abstraction, of which the second and third are directly managed by SeLeNe:

- the LO content,
- the LO descriptions, and
- the LO metadata standards and domain/task-specific taxonomies.

3.2 Retrieving Learning Objects

Users access a SeLeNe by contacting a known node, and can issue retrieval requests from the SeLeNe node they are logged on to. From a user's point of view, the formulation of a retrieval request and the result returned are independent of the physical distribution of LOs over the SeLeNe. For retrievals that return a large number of LOs, it may be that they could be returned to the user in 'chunks' as they become available, rather than as one complete set of LOs.

Three alternatives, of increasing sophistication, will be available for users to retrieve LOs that are accessible to them on the SeLeNe:

(1) By browsing through the LO schemas and taxonomies.

(2) By keyword search over LO descriptions.

(3) By annotated keyword search, augmenting the keywords specified with metadata properties from the LO schemas and taxonomies.

Retrieval requests may be either directly on the LO information space or on a personalised view of the LO information space. SeLeNe's retrieval facilities will be used both by potential learners and also by potential authors wanting to find LOs to retrieve and possibly use to create new LOs.

In (1) above, the quality of the browsing experience will depend on the quality of the LO descriptions[2].

For the LOs retrieved by mechanisms (2) and (3), users would have a choice of having either an unordered set of LOs being returned, or a set of LOs which are ordered into *trails*, i.e. into sequences of LOs reflecting possible orders of consumption of LOs which

[2]We note that (1) is analogous to the 'selection via structure map' scenario of Löser, Grune and Hoffman (2002).

are appropriate for the user's expressed learning needs and goals[3]. There could also be facilities for query refinement, i.e. asking a more focused query posed with respect to a previous query's result set. It is important to provide the result set in a meaningful manner so that learners can understand why they have been presented with this information in response to their query, and perhaps to make a choice of their preferred possible trail or LO.

In (2) above, a query is keyword-based and in its most basic interpretation is simply a conjunctive query. The search will be restricted to a small set of common metadata properties from the LO schemas and taxonomies. For example, a simple query would be

Newton calculus

This will search for all descriptive items within the predefined set of common metadata properties which are relevant to the query in an information-retrieval sense (e.g. stemming, proximity matching). In the above example, results could be returned from the *title*, *creator* or *subject* metadata properties.

In (3) above, simple keyword-based search is augmented with specified metadata properties, and these may be any properties from the LO schemas and taxonomies accessible to this user. Thus, if in the above example results are required where 'Newton' is the *author*, then the query would be specified as

author:Newton calculus

and if we wish to further restrict the query to results where 'calculus' is (part of) a course name, then the query would be specified as

author:Newton *course*:calculus

For this kind of querying there will need to be automatic translation between different taxonomies, for example to pick up equivalent terms for *author* and *course* above. This will include use of different natural languages for expressing such metadata elements, and will be part of SeLeNe's *syndication service*.

Finally, it is an important issue to consider user interfaces apart from the standard search-engine one, and in particular the use of forms which make the use of metadata properties as easy as possible. However, detailed GUI design is beyond the scope of the present SeLeNe project.

3.3 Personalisation of Query Results

Personalisation will have an effect on the filtering and ranking of the LOs or trails that are retrieved as a result of a user's query, and will entail the following aspects:

[3]We note that (2) and (3) are analogous to the 'selection via search' scenario of Löser, Grune and Hoffman (2002). We have already referred in previous footnotes to another two of their four scenarios: 'instructed access' and 'selection via structure map'. Their fourth scenario 'problem oriented access' is not so relevant to us as it is concerned with the content of learning objects, which is outside the scope of the present SeLeNe project.

(1) *learner profiles* – for example, age, preferred languages, educational background, interest, learning objectives and current levels of knowledge; such information will help the SeLeNe match the user's preferences against the results of a query in order to generate a possible ranking;

(2) *author profiles* – similar to learner profiles but clearly authors have a different perspective, which is related to their background and the type of material they are providing;

(3) *class profiles* – will include teaching-related issues such as information about tutors, and also aggregate information collated from the individual learner profiles of members of the class;

(4) *history* of LO access – recording the history of LOs that a learner has accessed will help avoid re-presentation of material already covered, and will aid both the learner and the SeLeNe in selecting future LOs;

(5) *adaptivity* – the SeLeNe should adapt a learner's profile as the learner acquires new skills, knowledge and interests; we thus need to investigate ways of augmenting what a learner knows after they have 'learnt' from consuming a particular LO or trail of LOs; adaptivity may also be appropriate for author and class profiles.

3.4 Trails

As a learner retrieves and consumes LOs, he or she is following a *trail*. The trail that is followed may or may not be useful in the context of the learner's learning objectives and current levels of knowledge. A primary concern for learning technology, therefore, is to support the creation, retrieval and modification of useful trails. Each trail will have a *degree of usefulness* in relation to a set of learning objectives and the individual profile of the learner (see Levene and Peterson (2003)) This conceptualisation of the learner's activity allows us to identify a particular role for the technologies developed under SeLeNe, i.e. supporting trail-based learning. This in turn implies a view of trails as first class LOs, which will have their own descriptions conforming to an appropriate schema.

We can distinguish between several types of trails according to their mode of creation:

(1) *authored trails* – trails that have been explicitly specified by a SeLeNe user; for example, by a teacher, in order for a class of learners to achieve specific learning objectives; or by an expert on a subject tailored to a particular community of learners; or by a learner for their own individual learning purposes;

(2) *derived trails* – trails that are derived by SeLeNe from LO descriptions according to specific criteria; for example, taking into account learners' progression, subject, level and other learning objectives;

(3) *emergent trails* – trails that are recommended by SeLeNe as a result of observing the history of browsing and retrieval of LOs; emergent trails may be

(a) *personal trails* – arising from an individual's browsing/retrieval activity; or

(b) *collaborative trails* – arising from a group's browsing/retrieval activity.

SeLeNe will support trails as a form of composite LO, and will thus provide facilities for creating, modifying and sharing trails. Each trail will have its own description and also information dependent on the relationship it bears to a particular learner's profile. For example, an individual's perception of the trail's usefulness may be influenced by the identity and affiliation of the author of the trail.

4 Comparison of SeLeNe with LMS and ITS

SeLeNe is mainly complementary to traditional Learning Management Systems (LMS) (we refer the reader to Appendix A for a detailed review of Learning Management Systems and Learning Object Repositories):

- **Presentation of Content** — LMS act as delivery systems for the presentation of learning content to learners. In contrast, SeLeNe is an 'intelligent catalog' allowing the registration of LOs and the discovery of useful LOs via their associated metadata.
- **Assessment and Tracking** — LMS perform administrative functions such as tracking the progress and attainment of students. SeLeNe has no knowledge of this kind. It may be used to discover LOs that can be used for assessment, but their validation is beyond the scope of SeLeNe.
- **Communication and Collaboration** — LMS often have tools that allow asynchronous communication based on email within a group of users (e.g. an instructor and his class). SeLeNe goes beyond this in its envisaged 'reactive' functionality that will allow automatic notification of events and changes in LO descriptions.
- **Search** — LMS may allow search across LOs at a single site, usually searching for keywords within the LO content itself. SeLeNe allows searching of LOs at many distributed sites, via their descriptions rather than their content.
- **Personalisation** — Personalisation in LMS tends to be concerned with remembering which courses the user is allowed to view, and how they like their pages to be presented. In contrast, SeLeNe provides a wide range of personalisation techniques based on profiles, views and trails.

Some of the proposed functionality of SeLeNe has parallels with that of Intelligent Tutoring Systems (ITS), although SeLeNe's scope is generally wider. ITS use knowledge about a domain, the student, and teaching strategies to tailor learning and tutoring to the individual, sequencing the domain knowledge in the best way possible for the learner. They often take the form of a hypertext or hypermedia system where an initial student assessment is performed using multiple choice questions. Following the assessment one

of two things can be adapted: the content of a hypermedia page ('adaptive presentation' or 'content-level adaptation') or the links from a page ('adaptive navigation support' or 'link-level adaptation').

In SeLeNe, the domain knowledge is captured in the LO descriptions and the student's knowledge in the user profile. The selection of teaching strategies comes from the combination of the two. The personalised trails generated by SeLeNe are analogous to the individualised sequencing of knowledge in an ITS, although only retrieval support can be supplied by SeLeNe as it does not interact with the content of the LOs themselves, only with their descriptions.

With ITS the adaptation and navigation support is *within* a single LO. With SeLeNe, however, these activities are at the inter-LO level, with support being provided for navigation between different LOs rather than within a single LO. In fact, an ITS could be one of the LOs dealt with by SeLeNe — an Intelligent (hypertext) Textbook, for example.

5 Novel aspects of SeLeNe

As an Accompanying Measure, the SeLeNe project is intended to complement other similar, parallel projects. Thus, in this section we briefly compare the envisaged functionality of SeLeNe with that of four related systems: Edutella[4], Elena[5], UNIVERSAL[6] and SWAP[7].

Edutella (Nejdl et al. (2002)) provides a peer-to-peer infrastructure for connecting peers supporting different types of repositories, query languages, and metadata schemas. Each peer implements a number of basic services such as querying, replication and mapping between different schemas. Elena (Simon et al. (2003)) provides a mediation infrastructure for learning services, where these might be provided by assessment tools, LMS, etc. It includes dynamic learner profiling using 'personal learning assistants'. UNIVERSAL is a business-to-business brokerage platform aiming to support higher education institutions in the exchange of learning resources. It allows institutions to advertise their learning resources, and provides a RDF-based catalog which can be browsed to find and access learning resources. SWAP (Broekstra et al. (2003), Ehrig et al. (2003)) does not address e-learning specifically but is investigating the integration of semantic web and peer-to-peer technologies in order to support knowledge sharing. It is developing technology both for allowing users individual views of knowledge and for effective sharing of knowledge. It has its own RDF repository and associated query language, the ability to define views, and also supports propagation of updates.

Looking at some of the major aspects of SeLeNe's functionality, we can draw the following comparisons with the above systems:

- **Registration of composite LOs dependent on other atomic or composite LOs**

[4] http://edutella.jxta.org/
[5] http://www.elena-project.org/
[6] http://nm.wu-wien.ac.at/universal/
[7] http://swap.semanticweb.org/

SeLeNe users will be able to register with the SeLeNe new composite LOs. These are LOs which have been created as assemblies of existing LOs, which themselves may in turn be either atomic or composite. SeLeNe will be able to automatically derive the taxonomical description of a composite LO from the taxonomical description of its constituent LOs. Composite learning objects do not seem to be addressed specifically by any other project.

- **Definition of personalised views over the LO descriptions and schemas**

  SWAP provides users with the ability to define views over RDF descriptions. In contrast, SeLeNe will allow views to be defined over combined RDFS/RDF descriptions i.e. over both the LO descriptions and their schemas. Another novel consideration in SeLeNe is the compositionality of queries with such view definitions.

- **Event notification services**

  This has been proposed to assist in rule-based clustering of peers in Edutella (see Löser et al. (2003)), where the events correspond to peers connecting to, or disconnecting from, a super-peer. SeLeNe's events, on the other hand, operate at the level of LO or user descriptions, e.g. registration, retrieval or update of LO descriptions. UNIVERSAL does provide notification via email of new published learning resources in a particular discipline. SeLeNe's notification services will go beyond this by allowing personalised notification depending on users' profiles[8].

- **Syndication services**

  Elena and Edutella both address this feature through Edutella's mapping service which supports mapping terms from one schema to another. SeLeNe's services are similar to this. SWAP also considers the overlap between ontology definitions in order to extract shared ontologies for individuals or groups of people.

- **Support of trails**

  The concept of an 'episode' is considered by Löser, Grune and Hoffman (2002) and these correspond to what SeLeNe classifies as 'authored trails'. SeLeNe's derived and emergent trails do not seem to have been considered in other projects.

- **Support of assisted and unassisted learning**

  Assisted learning is supported by 'episodes' and other forms of aggregated LOs. Unassisted learning will be addressed in Elena through the use of a personal learning assistant.

- **Support for a variety of query modes**

[8]SeLeNe's automatic detection and notification of events and changes is reminiscent of event-condition-action rules (or triggers) in active databases, and we are investigating this technology for providing SeLeNe's reactive functionality.

Specification of learning needs and current level of knowledge will be addressed in Elena through the use of a personal learning assistant. How the leaner actually interacts with the system does not seem to have been addressed in detail so far. UNIVERSAL supports similar querying facilities to SeLeNe, but not querying against personalised views and not personalisation of query results.

- **Support of personalisation of query results**

  This will be addressed in Elena through the use of a personal learning assistant, although it is not clear so far what its precise functionality will be.

6 Exploitation Scenarios for SeLeNe

The use of e-learning is now ubiquitous across all learning domains: it is used in schools, colleges, universities, the corporate training sector and by individuals. LMS, virtual learning environments and learning object repositories all have their place in the e-learning spectrum, so we conclude this report by examining where SeLeNe fits in relation to these.

In particular, in this section we highlight some of the problems that SeLeNe will help to solve that are not catered for (or that are insufficiently catered for) by existing systems, by means of several exploitation scenarios.

6.1 Active Learning Scenarios

'Active Learning' involves taking information, structuring it to create mental models, and then testing those models to check that they work. The creation of models is made easier if the information being used to build them is encountered in a logical sequence — with earlier material providing support for the correct assimilation of later material into the model. Both learners engaged in Active Learning and instructors wishing to support Active Learning would be helped by a SeLeNe:

- **Exploratory Learning**

  Exploratory learning usually happens when a learner has a task to carry out or a problem to solve. The first stage of solving a problem is to assemble the necessary information and the second is to structure it in such a way so that a solution to the problem is facilitated. The retrieval capabilities of SeLeNe address the first stage of the process, and its support for trails addresses the second. For example:

  – A student is doing research for an essay on Frege's philosophy of language and uses the UK's Philosophical Intercollegiate SeLeNe to search for information. As well as retrieving references to books by Frege, commentaries on Frege and general philosophy of language texts, the student is also presented with a collection of trails through this material – some authored by philosophy tutors and others authored by students who previously had to write a similar essay. As the trails

have been suggested by the wider philosophical community the student can be relatively sure of encountering the information in an order that leads to much easier comprehension of the subject matter than would result from attacking the references randomly.

- **Assembling course material**

  A good course in any domain will present material in a way that supports learners' construction of knowledge. Often the only way to tell which ways work better than others is through a process of trial and error. A SeLeNe can help instructors and trainers assemble courses and order material for a particular audience by containing trails authored by a community of people in the same business. For example:

  – A new secondary science teacher is about to teach the life cycle of plants and cannot decide whether to start or finish with seed dispersal. Several trails can be retrieved from the Schools Science SeLeNe and the teacher can see how other teachers have approached the problem in the past. The metadata associated with the trails could include details of how successful the different approaches were, and so would inform the decision of how to structure the course.

- **Notification services**

  Users may wish to be automatically notified of the occurrence of certain events in a SeLeNe. SeLeNe's event notification services will allow users to specify which kinds of events they are interested in and wish to be notified of. For example:

  – Users will be able to register their interest in particular topics that are associated with LOs, so that when a new LO related to a user's topic of interest is registered, the user will automatically be notified about its availability.

    To illustrate, consider a Spanish-speaking user who is interested in Economics and has registered to be notified if new material relating to this topic is added to the SeLeNe. The addition of a new book about Game Theory, for example, will trigger the event notification mechanism. The metadata for the new book is then checked against the user's personal profile — the book is written in French, and this is not recorded in the user's profile as a language that the user speaks, so no notification is given. When a Spanish version of the book is registered with the SeLeNe two months later, the event notification mechanism is again triggered, and this time will let the user know about the new LO as the personal profile shows that the user is a Spanish speaker.

  – A teacher may ask to be notified of when her students access particular LOs, in order to find out which material is most useful to students.

  – A teacher is marking some coursework essays and has noticed that several students have used similar arguments to reach the same conclusion. By checking

which LOs have been accessed by which students the teacher can decide if they have probably copied one another, or have simply been using the same source materials.

- During a lecture, the lecturer mentions that he is creating several LOs that might be useful for one of the coursework assignments. Students can go away after the lecture and request notification of new LOs registered by their lecturer. When these LOs are added to the network by the lecturer, students will be immediately notified of their availability.

6.2 Just-In-Time Scenarios

- **The learner in a hurry**

  Within all walks of life situations may arise where new knowledge or skills are needed but the time or resources for proper training are not available. For example:

  - The boss of a web-design firm might tell an employee "you need to know about the workings of the accountancy industry for a meeting with a potential client from an accounting firm next week." There is no time to arrange for any formal training on the sector involved, and almost certainly no internal training material available. A SeLeNe could help in this case by using the employee's personal profile, combined with a query 'accounting basics', say, to select a trail of LOs that will give an overview of the sector at the level needed by the employee.
  - A student realizes she has a test the next day on a subject she has done no revision for. There is no time to cover all of the course notes but her institution's SeLeNe should be able to quickly identify for the student some suitable high-quality review material, possibly utilising the student's personal profile.

- **The instructor caught 'on-the-hop'**

  Instructors always do their best to be prepared for the classes they are going to take, but occasionally they will find themselves faced with a different situation from that anticipated and need to produce new material in a hurry to cope with the situation. For example:

  - A trainer for an estate agency with offices around the UK arrives at a regional branch prepared to teach new staff about their obligations under the Property Misdescriptions Act (1991). The branch manager asks him if he can instead cover the Estate Agents Act (1979), due to a recent highly publicised lawsuit regarding a breach of it. The trainer is knowledgeable about this but doesn't have the right resources with him. By logging on to a Corporate Training (or a Legal Training) SeLeNe he can retrieve slides and handouts relevant to the new subject for the day's training in a matter of minutes.

6.3 Resource-Sharing Scenarios

The creation of good learning resources is a time-consuming process. For example, instructors at different institutions, and sometimes even within the same department, will often spend time creating their own learning resources to aid teaching of the same topic. This constant 're-invention of the wheel' is a waste of instructors' precious time, but is often still quicker than trying to locate and use learning resources that already exist. It would be much better if resources could easily be shared with other instructors in the same field and if existing shared resources could be easily found.

- **Sharing and collaboration within a community**

  This everyday problem is partially solved by the establishment of communities of people (both between and within institutions) who collaborate in the creation and sharing of resources. A SeLeNe could greatly enhance the experience and productivity of these communities, for example:

  - School departments usually have a set scheme of work, with an associated collection of resources to help teach it. Often the resources will not be exactly what an individual teacher wants to use to cover the curriculum though, and so they produce some extra resources of their own (e.g. maybe there are pupils who need special resources such as larger type, simpler language or different colours). Often the use of these extra new and adapted resources will remain restricted solely to the teacher that produced them. A school-wide SeLeNe would allow these extra resources to be easily shared with colleagues and the associated metadata would ensure that they are easily found when needed (e.g. the metadata could represent the fact that "This is lesson 12's worksheet with a larger font face").

    This example would easily extend to a consortium of schools that each has individual schemes of work, but adhere to a common curriculum (such as the UK's National Curriculum). In this case teachers could use the SeLeNe to easily find a selection of resources covering the same subject matter in different ways, and select the material most suitable for the pupils.

  - In a similar scenario to that above, a SeLeNe can be used to bring experts in different areas together to collaboratively construct high quality university courses. So experts in different areas can contribute LOs to an overall set of LOs, as well as collaborate in creating 'trails' through this material for defining specific courses.

- **Changes to LOs**

  LOs in a SeLeNe may change over time as their authors update them. Users of LOs can choose to be notified of changes that are made to the LOs' descriptions, and may

choose to automatically update their personal trails according to such changes. For example[9]:

- While using a LO for an Art History course a user realizes that a picture shown as an example of a Rembrandt has recently been found to be a forgery. They contact the author of the LO, who updates it with a different picture that is still believed to be a genuine Rembrandt. Users of the LO who have subscribed to the appropriate change notification service will be automatically notified that this update has taken place. For one of the users of the LO, the update sparks an interest in forensic investigative methods that leads to further research in the field and successful identification of many other misattributed paintings.

- **Creation and Update of Composite LOs**

  One function of SeLeNe will be the capability to create composite LOs from other LOs. If a LO's description changes, it will be possible for authors of any dependent LOs to be notified. For example:

  - An author of a worksheet for a school science experiment has used a diagram from elsewhere showing how the equipment should be set up. The author of the diagram, a teacher at a different school, changes the diagram when a consignment of new science equipment arrives at that school. The author of the worksheet is notified that the diagram's description has been updated, but she elects to keep a copy of the original diagram in her worksheet as the equipment shown in the new diagram is not yet available at his school.
  - A LO designed to be used within management training courses is regularly updated to reflect the most recent trends in management theory and practice. Any company that wants its managers to be au fait with the latest methods and theories will want to be notified when a new version of the LO is released so that its management training courses can be upgraded. SeLeNe can do this by detecting changes in the LO's description.

6.4 Comparison with Salmon's four 'Planet' Scenarios

In her keynote lecture at ALT 2001, Salmon described four possibilities for future teaching and learning environments (Salmon (2001)). Her scenarios look at the different kinds of hardware technology that may be available, and the new kinds of pedagogy that might emerge from their use. The metadata management given by the middleware technology of SeLeNe is in some senses 'hardware-and-pedagogy-neutral' and so could potentially fit into any of Salmon's four 'planets'.

[9] We recall that in this and the next bullet point, SeLeNe will provide such automatic change detection and change notification facilities by comparing the old and the new descriptions associated with a LO, not by examining the old and new LO content (see Sections 3 and 3.1)

In Salmon's scenarios, technology is seen as a passive entity to be used and manipulated in new ways by instructors and learners, and the reactive functionality provided by SeLeNe adds an extra dimension to some of the situations she describes. SeLeNe's trails are also adaptable enough to be useful across all four of Salmon's scenarios. The following points indicate where the functionality provided by SeLeNe could fit into Salmon's four scenarios:

- **Planet Contenteous.** Many of the LOs whose metadata is managed by SeLeNe will probably be designed with the 'transmission' model of teaching in mind, and they will eventually be delivered to users via the traditional e-learning route of a content/learning management system. Trails could be a series of LOs presenting aspects of a topic in a logical sequence, ending with a test on the material covered.

- **Planet Instantia.** Our Just-In-Time scenarios of Section 6.2 show how SeLeNe can help with the delivery of Computer-Based Training in the workplace as and when needed, according to individual user profiles. The reactive functionality of SeLeNe could play part of the role of the 'virtual trainer', suggesting new LOs as they are registered with the system, which will help with a user's ongoing development needs. Trails could be a collection of LOs that together address an immediate information need of a particular user.

- **Planet Nomadict.** If SeLeNe provides an interface for mobile, hand-held and wearable devices — allowing search of the metadata repository wherever and whenever needed — then it can be involved in learning on Planet Nomadict. Salmon says that "pedagogy is various so learners choose based on their cognitive preferences", but the profiling and notification mechanisms of SeLeNe should be able to suggest LOs based on the pedagogy of choice without the user being troubled for an explicit decision each time. Trail generation can take account of location and time (as well as the rest of the user's profile) to present the most immediately useful LOs to the user.

- **Planet Cafélattia.** SeLeNe's functionality may be at its most useful when integrated into a learning community — the support of a community of instructors and learners to provide reliable and trustworthy metadata ensures that the most is made of SeLeNe's capabilities. On this planet "a key activity for learners is finding and interacting with like-minded individuals". Event notification mechanisms in SeLeNe could notify users when like-minded individuals (as judged by their personal profiles) join the network or are on-line, greatly simplifying this key activity for learners. Useful trails are explicitly authored by the community and also emerge from their behaviour over time.

In summary, Salmon's planets are distinguished to show how future technology might affect the different roles that instructors (specifically, university teachers) will have to play, and the new types of learning relationships and assessment strategies that are made possible. Many of these changes will be brought about by the new kinds of learning and assessment material available. As SeLeNe does not look into the LOs themselves, it is

neutral with respect to the differences in approach of the LOs it deals with, making it versatile and applicable across all four planets.

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A Learning Management Systems and Learning Object Repositories

Learning Management Systems (LMS) are systems that support the creation (via authoring tools), storage (for example in a relational database) and presentation (often via a web browser) of learning materials in a structured way. They often also include 'tracking' tools that allow for record-keeping on students enrolled in courses, and usage statistics for the system as a whole (one of the most important of these being statistical analysis of students' responses to questions, which enables validation of testing on the system).

Learning Object Repositories (LOR) are collections of learning resources with associated metadata, generally available and searchable via the Web.

LMS are usually designed to deal with LOs at the 'course' level of granularity, whereas LOR tend to operate with much smaller units – generally individual web pages, multimedia objects (images, video, etc.) or programs. The 'courses' dealt with by LMS are an aggregation of the kinds of object found in LOR.

Both LMS and LOR are relevant to the SeLeNe project as SeLeNe will encompass elements drawn from them – the authoring support of a LMS with the storage and search facilities of a LOR. There are many LMS and LOR in existence, and the collection presented here is by no means comprehensive. However, we believe that the collection here gives a fair picture of the state-of-the-art of LMS and LOR at this time.

A.1 Learning Management Systems

A.1.1 Blackboard

- *The System*

Blackboard claims to provide "a total e-Education Infrastructure" for schools, colleges, universities, and other education providers. The system can be installed locally at an institution, but they also offer remote hosting of courses on their own servers. As well as content management it provides various facilities including a bulletin board, calendar, active conferencing and quiz tools.

- *Licence*

  Blackboard is a commercial product – annual licences can be purchased for an installation locally (£4,400 for the Basic Edition, £15,000-£37,000 for the full learning system – with actual cost depending on the number of students at the institution), or a remote ASP hosting service can be bought.

- *Technology*

  Blackboard runs on relational databases and they claim it can be scaled to support tens of thousands of users by means of a multi-server configuration. It has a basic 3-tier architecture (Database back-end, Web Server in the middle and Browser at the front). For a local installation it appears that Sun Solaris and Red Hat Linux are the only platforms supported.

  The latest release of Blackboard supports SCORM specifications and sharable content objects by including a 'player' for SCORM objects. However, this does not mean that metadata specifications are necessarily adhered to - just that imported objects that do have metadata can be used in the system. Content authors do have the option of adding metadata to their objects, but it seems that often this consists of just a free-text description of the object. There is support for IMS metadata specification to allow for IMS compatibility when content is imported and exported, but its use does not seem to be particularly encouraged by Blackboard.

- *Content Management*

  The import and export of content seems to be easiest at the 'course' level of granularity - entire courses can be zipped and unzipped as packages quite easily.

  Since January 2002 there has also been support for content exchange at 'Content Module' granularity via Prometheus - an open source software platform acquired by Blackboard. Prometheus allows the import and export of coherent modules to and from courses. It also enables the creation and modification of these modules by adding content to and removing content from a module. Modules can be shared with other instructors at the same institution (so only one copy of the module needs to exist in the system for it to be used in several courses), and can be transferred to other institutions, if the creator of the module chooses to do so. However, no mechanism seems to exist for the sharing of modules openly between instructors either within or between institutions, and hence there is no way to search for existing content.

  While user-created content cannot easily be shared or searched, publisher-created (i.e. commercial) 'course cartridges' are held in a searchable repository and can be

downloaded (usually for a fee) for inclusion in courses. The cartridges must have some metadata associated with them in the repository as they can be can be searched by Discipline, Author, Title/Keyword, ISBN, and Publisher. However, this metadata does not conform to any standard specification.

Amending Blackboard courses once published (e.g. adding a page of content or changing a question on a test) is difficult, and often the easiest method is to rebuild the whole learning path (a component of a Blackboard course) over again.

Student log-in is done by single-sign-on integration with an institution's existing authentication protocols - they claim it will work with SITS, Capita, SCT, PeopleSoft, Datatel, LDAP, Kerberos, as well as any other custom or proprietary system.

- *Search*

  All courses offered by an institution can be searched in a 'course catalog' available at the main Blackboard portal page at the institution. Users can search for courses via keyword or browse by category (the categories of courses are set by the system administrators).

  Once within a course there doesn't seem to be any support for searching the course material itself.

- *Personalisation*

  There is no personalisation of the learning experience – the system remembers which courses a user is registered for but that seems to be all the personalisation that is done.

- *Event Notification*

  Courses can be changed by authors as they are running. There seems to be no automatic notification mechanism within the system for when this occurs.

- *Future Development*

  Future development of the system seems now to be in the hands of the users themselves – since the introduction in December 2000 of the 'Building Blocks' programme any user can build their own application extension and distribute it through the Blackboard repository of 'Building Blocks'. Users can pick and choose which features they want in their system from existing building blocks, or can build their own if a suitable one is not available.

  Examples of currently available building blocks include a science toolkit (mainly mathematical calculation tools), dictionaries, a link-checker for course authors to validate external links, content authoring tools, collaboration tools and the SCORM compliant player mentioned earlier.

  This open development should ensure that Blackboard will keep abreast of developments in technology and e-learning systems.

A.1.2 Future Learning Environment (Fle3)

- *The System*

  Fle3 is server software for computer supported collaborative learning (CSCL). It supports learner and group centred work, enabling and encouraging collaboration and communication between learners taking the course.

  The learning environment consists of:

  - A 'WebTop' that holds items much like the Desktop in Windows. Users can store and organise objects (documents, files, links) here. There is a shared 'course folder' that any user can access, allowing the sharing of resources between learners. The website says that "the items in the WebTops can be called learning objects - if you wish".
  - 'Knowledge-building tools'. These are tools that allow communication, discussion and debate among members of the learning group – basically notice boards that users can read and post messages to.
  - 'Jamming' area — this is a shared space where digital artifacts (pictures, text, video, audio) can be constructed collaboratively. There is version control, and all past versions of the object can be seen in the space.

  Although the system could be used to manage and deliver course material in the same way as WebCT or Blackboard the emphasis is much more on encouraging learning through debate and collaboration. Rather than providing a whole set of course material, teachers are more likely to populate a course environment with a few 'starter' objects and a couple of topics for discussion, and let the learners themselves develop the workspace.

- *Licence*

  Future Learning Environment is free, open source software released under the GNU GPL.

- *Technology*

  Fle3 is a Zope product (Zope is an open source application server), written in Python. Zope and Fle3 run on GNU/Linux, MacOS X, *BSD, and Microsoft Windows.

  As the focus of the system is on providing tools for collaboration, rather than on content development and management, no metadata is used to describe objects - they are just shared 'as is' between learners on a course.

- *Content Management*

For teachers and administrators Fle3 offers tools to manage users and courses/study projects. The administrator may also export and import courses or the entire content of the Fle3 database in XML format (compatible with the Educational Modelling Language - EML).

There is support for the collaborative development of resources for use by a learning group provided by the 'Jamming' tool, but teachers must create their own resources outside of the system and add it to the shared folder of the WebTop if they wish to provide content themselves.

- *Search*

  There seems to be no support for search in Fle3 – either within a course or for material between courses.

- *Personalisation*

  There is no direct support for personalisation of the individual learning experience. However, the system is open source, so the interface and functionality can be customised by users.

- *Event Notification*

  There is no notification to users of changes to the learning environment - it is up to them to explore and find new material as it is added.

- *Future Development*

  No details of future development plans are available, but as the project is open source it may be up to the users which additional features are added to future versions of the software.

A.1.3 .LRN

- *The System*

  The .LRN (dot LRN) is a portal framework and integrated application suite developed at MIT that supports course management and online learning communities with personalised content

  The .LRN is based on a modular architecture that permits flexibility to merge a variety of technologies. It is based on the Web Services paradigm, permitting horizontal integration of both open source and proprietary technologies.

- *Licence*

  .LRN is a fully open source e-Learning platform. The .LRN is being made available as open source software under the GNU General Public Licence (GPL).

- *Technology*

  .LRN has a strong relationship with some of the best research and technology initiatives at MIT – including Open Knowledge Initiative (OKI), DSpace and iCampus. The development of the system is based on two basic components:

  – AOLserver – the open source web server of AOL

  – OpenACS – a web toolkit for building scalable database-backed web sites.

  It is also compatible with Oracle and PostgreSQL.

  Currently the .LRN is in beta condition and does not fully support any metadata standard. It is planned that the first stable version of the platform is programmed to be fully compatible with IMS and SCORM standards. At the moment there is only partial support for the IMS System – the IMS Content Packaging System is used for data transfer across the network in the form of XML.

- *Content Management*

  Authentication

  The authentication system of the .LRN is based on the classic login system. Users send a request for registration on a course to the system administrator. Once the user is approved and registered an e-mail address and password must be submitted for log-in. This is done at a secure web page in order to ensure password security. The system does not remember any passwords.

  Material Management

  The .LRN is characterised by flexible resource management and there are many types of resource material available. There are user groups organised into classes of interest and communities which share information about specific events and information.
  The user is able to register for events of interest using a calendar (daily, weekly and monthly), and can store personal files and bookmarks in their space on the system. They can also submit homework or coursework for a course – the submission is timestamped.

  As well as the characteristics above, teachers also have access to a 'control panel' where they can manage memberships, subgroups, calendar events and all methods of communication with students. The control panel can also be used to access tools to create new items, surveys, FAQs and to send bulk e-mail and homework notifications. The teacher is responsible for modifying the content of the courses, publishing them on the Web and posting changes and news.

- *Search*

  The main method of navigation through available resources is to browse them by category. The resources are currently divided into three main categories: Interest Groups, Forums and News. Users can browse through the available categories and

choose groups they are interested in to join. Currently there is no way to search by keyword or any other type of search. Later releases of the platform will probably support it.

- *Personalisation*

  One of the most impressive characteristics of the .LRN is its great flexibility in personalising the environment. Instructors as well as students are able to personalise their environment to a great extent.
  Through the 'Control Panel' tab they are able to change almost any setting that concerns their account.
  The teachers are able to manage their classes and groups and fully customise the layout of the course.
  The students can join forums, courses or news groups that they are interested in, request change notification, store their personal files and maintain their personal calendar (monthly and weekly), which keeps track of their event transactions and much more.

- *Event Notification*

  The event registration and notification in .LRN is done by the use of a module. The event registration module was ready and tested in early 2003. The final integration of the module was expected soon after.
  Users can also request notification via email of changes in the forums the user is interested in.

- *Future Development*

  The .LRN is currently in a beta state. The .LRN is a continually developing project, and by the time of the first official stable release new features and functionality will have been added. The enhancement process has been undertaken by a number of forums that work on one topic each. The areas subject to improvement or that will be added are:

  (1) *Class Registration.* Enhanced expression of who should be in which classes or groups, in which role and what the joining criteria are. This can vary significantly from school to school and the tool needs to support individual specifications.

  (2) *Chat.* A chat-room program to provide synchronous communication between users.

  (3) *Curriculum.* Enables sequenced traversal of branched learning activities in online courses. Curriculum will allow educators to arrange learning resources, such as documents and tests, into syllabi within a general curriculum.

  (4) *Events.* The full integration of the event module was expected in early 2003 (see above).

(5) *Expansion of Survey Functionality.* Expansion of the current functionality to include scoring, sequencing and feedback.

(6) *External Authentication.* An attempt to make login services of .LRN independent of Authentication Technologies.

(7) *IMS and SCORM Standards.* Compatibility with IMS and SCORM metadata standards.

(8) *Internationalisation of the OpenACS Project.* Add support for more languages.

(9) *Archiving/Deleting Groups.* Provide a way to make old classes and communities in the system 'go away'.

A.1.4 MOODLE

- *The System*

  MOODLE is a software package for producing internet-based courses and web sites. It is an ongoing development project designed to support a social constructionist framework of education. The name MOODLE stands for Modular Object-Oriented Dynamic Learning Environment. It is a system that has been developed by a single man, Martin Dougiamas, as a part of his PhD Thesis. Its development started in 2001 and the current version of the platform is 1.0.6.4.

- *Licence*

  MOODLE is provided free as Open Source software under the GNU Public Licence (GPL). Basically this means that MOODLE is copyrighted, but that the user has additional freedoms.

- *Technology*

  MOODLE is built in PHP and can potentially support many types of database. Presently only MySQL is supported, but in later versions support is planned for PostgreSQL, MS-SQL Server, Oracle, Access, Interbase, Fox-Pro, ADO, Subase and DB2. The web server used is Apache.
  MOODLE was developed in Linux but it is platform independent. The software required is a working installation of PHP (version $\geq$ 4.1.0) and a working MySQL database installation. The MOODLE system does not use any specific metadata standard beyond the metadata provided by the underlying RDBMS. The next main release should have some basic support for IMS and SCORM.

- *Content Management*

  Authentication

  The whole platform is based on a very good authentication system. It supports a range of authentication mechanisms through plug-in authentication modules. Students can create their own login accounts by e-mailing to the system administrator.

Email addresses are verified by confirmation. Also LDAP can be used to check the account logins. SSL and TLS certificates are also supported.
Each person has only one account for the whole system – each account can have different access rights. The administrators control the creation of courses and create teachers by assigning users to courses. Instructors (of a course) have full control over the course content – they are able to add an 'enrollment key' to their courses to keep out non-students and can also unenroll students manually.

Material Management

Resource management is also very flexible. There are many course formats – they can be organised by week, by topic or as a discussion-focused social format. There is a wide array of possible course activities (including Forums, Journals and Quizzes). Recent changes to the course since the last login can be displayed on the course home page.

Modification and authoring of courses is done by the teacher. Students can upload their assignments to the server and send their feedback on some topics that the teacher allows.

- *Search*

  The contents can be searched by keyword or be browsed by course. Structured search is not yet supported.

- *Personalisation*

  Users are able to edit their own profile. This includes subscriptions to forums and watching courses. The capacity for personalisation of the environment is subject to be improved further in the next main release of the product.

- *Event Notification*

  The only event notification mechanism that exists in MOODLE is in the form of PHP script that runs periodically (e.g. through the program `cron` in Unix systems), checking the resources for changes and then notifying interested subscribers by sending an e-mail, for example to the subscribers of a mailing list.

- *Future Development*

  The next main release of MOODLE is expected to include some major new features such as :

  (1) Stronger pedagogy support for both teachers and students.

  (2) Support for groups and groupwork.

  (3) Rewritten display incorporating XML, XSL and CSS.

  (4) Basic Support for metadata standards IMS and SCORM.

  (5) A variety of new modules such as chat.

In the future some pay services may be offered, although the software itself will remain free.

A.1.5 WebCT

- *The System*

  WebCT claims to be the leading provider of e-learning solutions to the higher education sector. It offers two main products:

  - 'WebCT Campus Edition', which is a course management system designed to be implemented across a higher education institution. As well as content delivery and management it includes student performance assessment and tracking and communication tools such as whiteboard, discussion forum and instant chat room.
  - 'WebCT Vista', which is described as an "enterprise-class e-learning system" – it appears to do the same as Campus Edition, but with a few extra features such as role-based authentication, an SDK to allow application extensions to be built, and additional functionality in the communication tools, allowing 'cross-course' communication.

- *Licence*

  WebCT is a commercial product, cost according to number of servers required (maximum 3000 students per server) and the actual products supplied. The cheapest 'entry-level' system costs £4,500.

- *Technology*

  WebCT can be run on a range of platforms, including Sun, Windows, UNIX, and Linux. WebCT Vista uses Sun Microsystems Enterprise Java Bean (EJB) technology and is J2EE compliant. The multi-tier architecture includes a BEAWebLogic application server and an Oracle 9i database layer comprising Oracle 9i DBMS (Database Management System) and Oracle 9 IFS (Internet File System). It uses IMS-compliant metadata to hold information about the learning resources (XML DTDs can be downloaded from the WebCT website), and there is an IMS content-migration utility.

- *Content Management*

  Both editions of WebCT allow migration of content using an IMS compliant system (with data in XML format), but this does not allow searching for course material – it seems that the user needs to know that the content exists, then ask a system administrator to migrate it for them. WebCT Vista includes role-based access to content, which allows for ease of sharing within an institution (across course boundaries). It also allows direct sharing of content between different institutions, but only if they share a central installation of the WebCT software.

Support for authoring seems to be focused at the course, rather than the LO level. There is rudimentary support for the authoring of LOs within the system (little more than a text editor), but LOs (web pages that can include any embedded objects that HTML allows) can also be created outside of WebCT. The system interfaces well with external content creation packages, and Macromedia's Dreamweaver can be set up to automatically add and edit objects within a WebCT course. Authors need no special software to create courses from their existing LOs - just a browser and a network connection to the WebCT server.

Access to course materials is restricted to users registered for the course, and course administrators can release materials gradually and selectively (e.g. only when a student reaches a certain level of attainment). If the institution's computer system uses LDAP or Kerberos based authentication then WebCT integrates directly with this, otherwise it has its own custom login protocol.

- *Search*

  The only searching that can be done for learning resources is via a Java API to the Oracle database at the institution (metadata fields can be searched to help locate useful resources), making location of new content difficult, and nigh-on impossible if the content is at another institution. WebCT do provide their own learning content ('e-packs') which is available from the WebCT website (if you are registered with them) and which can be searched using a simple keyword search tool.

  Within a course search facilities seem quite good – course authors can automatically create a searchable index of the material to provide students with search functionality. If the author chooses to do this then students can search the available resources (within a course) by keyword. A searchable glossary can also be created by course authors.

- *Personalisation*

  WebCT claims to offer "highly personalized educational experiences", but in practice this seems to be mainly at the institutional, rather than individual level. The 'look and feel' of the system can be tailored to reflect the institution's branding (e.g. by the inclusion of a logo). Course designers can then also modify the layout and colour schemes of material further.

  WebCT can provide personalised learning paths for users, as access to objects can be conditioned on a wide range of personal data including achievement, date/time and class code (i.e. there may be many classes taking the same course, with different materials available to different classes). In reality this is seldom used to any great extent due to the high cost of developing learning materials in different styles and setting up courses to use these effectively. Personalisation at the level of the individual learner is usually restricted to allowing users to set individual bookmarks and providing a single-sign-on system – i.e. the system knows which courses a user is

registered for, and once signed in once all of these courses can be accessed without the need to sign in separately for each one.

There would seem to be a lot more scope for individual personalisation than this, as the WebCT system records quite a lot of information on the behaviour of the users (which documents they visit, how long they spend viewing them, test results and grades). At present this information seems to be used solely for the production of reports, but could be used towards providing a truly personalised educational experience without the need for large investments of course designers' time.

- *Event Notification*

  There is some event notification functionality in WebCT — students receive notification when new messages have been posted to a discussion forum or when the start date of a new assignment (as set by the course author) arrives. For other events it is up to the learners to find out for themselves that they have occurred – for example, if material is added to or removed from a course no notification is automatically given. There is a 'News' section for each course, so the course administrator could choose to add a news item or to send an e-mail to the cohort informing users of any changes made, but this is at their discretion rather than an automatic process.

- *Future Development*

  WebCT say they plan to incorporate more new technologies into the system and to maintain compliance with developing industry standards. The only example given is to add a SOAP web-services interface to the WebCT Vista SDK.

A.1.6 Xtensis

- *The System*

  Xtensis claims to be "a revolution in the management and delivery of eLearning" as it is specifically designed to handle LOs and their (IMS and SCORM-compliant) metadata. It is usable 'out of the box' as a learning management system, but can be configured to reflect the structure of an organisation and is more an architecture than a single product.

  It is used as the content management system for several UK-based LOR projects, including the National Learning Network (http://www.nln.ac.uk/), the Seeveaz Key Skills repository (http://sz.xtensis.co.uk) and Iconex (http://www.iconex.hull.ac.uk.).

- *Licence*

  Xtensis is a commercial product.

- *Technology*

  Xtensis is a client-server application built using Microsoft's DNA (Distributed interNet Architecture) design pattern. It keeps a repository of LOs and a separate

repository of metadata relating to the LOs. The LOs referenced by the metadata can be remote (available on the web or even physical objects) as well as stored in the local repository.

The Xtensis server is Windows-based (NT4/2000), and is a collection of COM components, ISAPI dynamic link libraries and ASP pages, the compiled parts of which are written in Delphi. The Sever uses Microsoft's ADO (ActiveX Data Objects) to communicate with databases, which gives native support for Microsoft Access, SQL Server, Active Directory and Oracle database access. It also allows connection to any ODBC data connection, so the system should be configurable with most DBMSs.

Content is delivered through a customisable web portal designed to work with version 4 and higher browsers. It uses HTML, DHTML, CSS and JavaScript.

- *Content Management*

  Metadata is used to describe all of the content in the Xtensis system. All fields of the IMS/CMI metadata specification are supported, and the system uses pluggable filters to convert other vendors' metadata implementations into a form compatible with Xtensis. Thus, with the right filter, Xtensis can import (and export) any LO that includes any 'reasonably conforming' set of metadata fields.

  There is no built-in support for the authoring, discovery or sharing of 'brand new' LO — the system is geared solely towards the delivery of LOs that have been acquired or created elsewhere. However, there is support for the authoring of two types of composite LO — 'path objects' and 'compound objects'. A path object has no 'content' of its own, but defines a linear sequence of objects from the existing repository. A compound object is made up from other objects in the system – e.g. a picture object and a text object could be put together to form a compound object that is a page with some text and a picture. These path and compound objects can then form components of other path and compound objects, allowing for the creation of complex LOs and hierarchies of paths through the LO space.

  There are tools that enable the easy marking-up of LOs with required metadata.

  Access to content that must be paid for is administered using the 'RightsCost' metadata field to hold machine-readable cost and copyright information. This information may also be described in natural language in the 'RightsCopyright' field.

- *Search*

  The local object metadata repository can be searched by users, but there is no support for the location of shared LOs elsewhere.

- *Personalisation*

  Xtensis keeps a very detailed student record that allows for much personalisation. As well as user interface preferences (graphics, colours, text size and font) and personal bookmarks the system stores a complete history of the LOs accessed by the user. This

history, combined with LO metadata can be used by the system to make 'intelligent suggestions' about which LOs are the best ones to present to the learner next. The factors considered by the system include:

- the language of the LO (compared with the preferred primary and secondary language of the student)
- the platform being used at the time
- the difficulty of the LO
- the intended age range of the LO
- prerequisites of a LO
- nearness in a taxonomy of subjects (ie. LOs dealing with the same, or similar topics)
- the preferred learning style.

So far there has been little use of Xtensis as an LMS to deliver content directly to learners, so the personalisation and intelligent suggestion features are yet to be extensively used. The base functionality of classifying users and LOs and making suggestions based on a mapping between them has been used (in work with Mencap) to automatically select versions of content based on users' learning difficulties or physical disabilities.

- *Event Notification*

  There appears to be no event notification mechanism within the system.

- *Future Development*

  Areas that are specifically indicated as work for the future are the extension of personalised suggestion mechanisms to include factors additional to those mentioned above, and the further development and implementation of an e-commerce model and digital rights protection.

A.2 Learning Object Repositories

The IMS Global Learning Consortium has recently (30th January 2003) released a final specification for Digital Repositories Interoperability (the 'IMS DRI'). They define a repository to be any collection of resources available via a network — either a collection of digital LOs or a collection of metadata describing such objects. The specification utilises existing IMS specifications for metadata rather than introducing new ones. It defines core functionality that a compliant repository should provide (including STORE, EXPOSE, DELIVER, SEARCH and REQUEST), as well as additional functions that can be provided.
As the specification is new no LOR vendors seem to have implemented it as yet. It is probably worth investigating further whether SeLeNe's data storage facilities should

conform to the IMS DRI specification but it would certainly seem at first that this is a good idea, allowing easy interoperability of SeLeNe's local repository with any Virtual Learning Environments (VLEs) or Portals in use at the site of the SeLeNe node. The problem might be that these VLEs and Portals will not support some of SeLeNe's more advanced features (e.g. event notification, change tracking, profiles), and so users bypassing the SeLeNe user interface will lose access to, and could in the worst case actually disrupt the correct functioning of, these features.

A.2.1 CAREO — Campus Alberta Repository of Educational Objects

CAREO (Campus Alberta Repository of Educational Objects) is a project supported by Alberta Learning that will create a searchable, Web-based collection of multidisciplinary teaching materials for educators across the province.

- *The Collection*

  The repository contains over 3000 varied multimedia objects such as video clips, images and electronic textbooks. Membership of CAREO is free and open to anyone. Members enjoy a variety of services including access to all sections of the site, personalised layouts and information delivery and Interactive Subscriptions Services. A guest login is also available for free, giving open access to the repository without submitting any details. Currently there is no difference in the access permissions of a member and a guest.
  The advantage of being a member comes from the ability to add objects and customise the CAREO site (see below).

- *Metadata*

  The metadata information is located into the so called metadata store which is structured according to the CanCore Learning Object Metadata Protocol[10].
  CAREO uses the ALOHA (Alberta Learning Object Hub Application) metadata markup tool as an aid for importing metadata to the repository. This is a Java-based tool, which is accessible via the CAREO portal, that allows the user to drag-and-drop media onto it and hence publish it in the repository.

- *Learning Object Authoring*

  The ability to author new objects and personalise the view of the CAREO site is a privilege for the members only. The content of the site is dynamic so the view can change depending upon the level of access you have, the profile you have created for membership or the time you enter the repository. When you have an active membership to the system you can dynamically add and remove new objects to your view and modify some of the existing ones. Guests have no access to this feature.

[10] CanCore is based on and fully compatible with the IMS Learning Resource Metadata Information Model. CanCore has defined a subset of data elements of this IMS model for the purposes of the CAREO project.

System administrators are able to modify the metadata and are allowed to change, update and modify the LOs.

- *Search*

  The CAREO repository has a keyword-based search interface. This searches keywords contained in the 'Title', 'Description' and 'Text' metadata fields of LOs within the repository. It is designed as a quick way to search through the repository content. Other search options include advanced search, which allows searching in other specific metadata fields, and browse LOs, which allows drill-down searches of the entire contents of the repository.

- *Personalisation*

  Members have full privileges for personalising their view. The users have the ability to store their notes about LOs and create bookmarks on LOs they find relevant (this is called 'subscribing to an object'), giving easy access to the same LOs in future once a useful LO has been located in the repository. Through an option in the web site they can see the information about their account. Here the user can modify account preferences, the way they view the site and the way the site views them. They can create a profile that will allow the repository to identify the particular areas of interest and allow for content updates of relevant material and communities. Also the number of LOs shown can be modified in the profile of the account.

- *Event Notification*

  CAREO does not notify all users of events that take place into the repository, but when a LO changes its subscribers are notified via e-mail that it has changed. There are also notification mechanisms via the web page or through the use of WebCT, with which CAREO is integrated.

A.2.2 European Treasury Browser

- *The Collection*

  The European Treasury is a collection of LOs that can be browsed on-line (at the European Treasury Browser). It is aimed mainly at schools in Europe, both for teachers preparing lessons and learners doing independent research. The project has partners in seven European countries, and the resources are in various languages.

  The aim of the ETB project is to build a Web-based Metadata Networking infrastructure for schools in Europe, to link together existing national LO repositories, encourage new publication, and provide a reliable level of quality and structure. In this sense its aims seem to be similar to those of SeLeNe.

- *Metadata*

Metadata is stored about the LOs in the LOR, but it does not seem to conform to any particular standard. The information stored is: Title, Language, Description/Abstract, Audience (Teacher, Pupil, Higher Education, etc.), Audience Age. The metadata is authored by whoever proposes the resource to be included in the LOR.

- *Learning Object Authoring*

  Anyone can suggest resources to be added to the LOR from a page on the website. A minimal set of metadata must be supplied with any suggestion. There is no support for authoring new material within the system – it is simply a repository for material that has been produced elsewhere.

- *Search*

  The LOs in the LOR can be browsed by category and searched by keyword. There is also an 'Advanced Search' option, which is quite limited – it allows 'AND' and 'NOT' operators to be applied, and search within a particular target audience and age range. A more complex structured search across all metadata fields appears to be lacking though.

- *Personalisation*

  Support for personalisation is limited – the website will remember how many results to return per page, and which is the user's preferred language.

- *Event Notification*

  There is no support for event notification at present.

A.2.3 MERLOT - Multimedia Educational Resource for Learning and Online Teaching

- *The Collection*

  MERLOT is a free and open LOR of about 3700 resources, mainly for use by the higher education sector in the US. It consists of a collection of links to learning resources (mainly web sites), and each link is annotated with metadata including peer-reviews and pedagogic information.

  No registration is necessary to use the repository, but if users wish to add LOs and reviews then registration, which is free, is required.

- *Metadata*

  MERLOT uses metadata elements that map to the IEEE LOM, and the LOM metadata can be exported from the repository as XML (but only by a select few system administrators and partners — not by the general visitor to the site).

There are future plans to implement a Web Service that will be able to search multiple collections at once (MERLOT and other partners), taking LOM input parameters and returning LOM XML (a subset of elements) as a result.

- *Learning Object Authoring*

  Registered users can add LOs (or their URL's at least) to the repository as they see fit. These could be authored by the member themselves, but any web-based resource can be added. When material is added by someone other than its author or creator, an email is sent to the person who owns it to let them know it has been listed in MERLOT.

  When a LO is added it may be subject to a structured peer review and scored (out of five) in each of the categories Quality of Content, Potential Effectiveness as a Teaching Tool, and Ease of Use. If a LO scores poorly in the peer review (below 3 out of five on average) it is removed from the LOR.

- *Search*

  The resources in the repository can be browsed by category, searched by keyword, or searched by a structured 'advanced search' on various metadata fields.

- *Personalisation*

  There is no personalisation available in MERLOT.

- *Event Notification*

  There is no event notification mechanism in MERLOT.

A.3 Lessons for SeLeNe

The main conclusion from this investigation is that almost without exception both the Learning Management Systems and Learning Object Repositories are weak in two areas:

(1) **Event Notification** — notifying users of the system when LOs within the system have changed since they last interacted with it.

(2) **Personalisation** — the personalisation that does exist tends to be either interface personalisation (what colours to use, how many search results to return) or authentication-related (showing only those courses or LOs that the user is permitted to access). There is no personalisation in the sense of creating an individual learning experience for users by presenting only material that will be pertinent to their needs.

If SeLeNe addresses these two issues (as it plans to) then it will certainly be filling a 'gap in the market'.

The multiple search interfaces used by most LORs seem to be a good thing — all of those we have seen allow browsing of the LOs by category and also employ a keyword

search. Most also have an 'advanced search' option which allows certain specific metadata fields to be searched. This range of search options means that users can choose the kind of search that suits their search style, or that they judge is most likely to be of use in satisfying a particular need. If SeLeNe implements other kinds of search it should probably be in addition to, and not instead of, the 'browse, search and structured search' interfaces.

The ALOHA metadata markup tool (see CAREO) seems useful. SeLeNe could include something similar to allow LOs' authors to easily mark-up the LOs they create.

Another interesting development is the proposed integration of CAREO with WebCT and Blackboard. While this is only a proposal at present, it will be worth keeping an eye both on how this particular project progresses and on whether integration of LMS and LOR becomes more widespread in general.

The 'LOM metadata metasearch web service' proposed for MERLOT is another development of relevance to SeLeNe in that it seems to be the only proposal for search that goes beyond the 'browse, search and structured search from a web page' paradigm adopted by other existing LORs.

A.4 On-Line Resources

Learning Management Systems:

Blackboard	http://www.blackboard.com
Future Learning Environment	http://fle3.uiah.fi/
.LRN	http://dotlrn.mit.edu/
MOODLE	http://moodle.com
WebCT	http://www.webct.com
Xtensis	http://www.xtensis.co.uk

Learning Object Repositories:

Canada SchoolNet	http://schoolnet.ca	Over 7000 resources, metadata search.
CAREO	http://careo.netera.ca	*See report for details.*
EdNA	http://www.edna.edu.au	Education Network Australia.
ETB	http://etb.jrc.it	European Treasury Browser.
GEM	http://www.thegateway.org	Gateway to Educational Materials: Inktomi Search over 26,000+ resources.
IMS DRI Spec.	http://www.imsglobal.org/digitalrepositories/	
Learning Matrix	http://thelearningmatrix.enc.org	Peer-reviewed LOR.
MERLOT	http://www.merlot.org	*See report for details.*
SMETE	http://www.smete.org	Uses LOM-based metadata.
UBP	http://www.educanext.org	Universal Brokerage Platform: Commercial repository with subscription at institutional level.