

Interoperability convergence of online learning and information environments

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INTRODUCTION

The purpose of this article is to describe the dynamics underlying the convergence of online learning and information environments as a means of exploring and explaining the current pre-occupation with the term interoperability. It will be a somewhat reflective and personal view of interoperability, based on my extensive involvement in the technical agendas surrounding the emergence of more coherent online learning and information environments within and across the education sectors in Australia and internationally. Whilst the principal focus will be on the technical agendas, it must be emphasised that the principal impediments to achieving concerted levels of interoperability are political in origin. Technology opens up new ways of doing things which inevitably challenge traditional power bases and interoperability agendas are often thwarted by the protection of “turf” at all levels within an organisation, or between organisations. It is my belief, however, that clear transparent technical agendas are the only answer to resolving territorial protection and the aim of this paper is to try and shed light on the complexities inherent in developing understandable and achievable technical interoperability agendas from the particular viewpoint emerging online learning environments.

INTEROPERABILITY AS A CONCEPT

There has been a great deal of debate about the term interoperability over the past few years, much of it being of a quite abstract nature. The principal flaw in much of the literature is that it is written from a purely technical perspective and it lacks a service context. Debates about emerging technologies, or clusters of technologies, are interesting but relatively meaningless unless the service or functional purpose is clearly stated.

The situation is made worse by the fact that there is much confusion at the conceptual level through the rather loose use of terms such as service models, information models, functional models and technical architectures. Each of these activities has its own particular discipline and interpretation although, ultimately, they are all integral to formulating and developing interoperability agendas. There is also a lack of agreement on how to depict these different, but interdependent, notions of interoperability in diagrammatic form, which thwarts consistent debate, particularly across service domains.

ONLINE LEARNING: THE COTTAGE INDUSTRY PHASE

Online learning has become one of the fastest growing businesses in the global arena. Whilst there are signs of considerable activity in some countries and in some sectors of education and training, the fact remains that online education environments are still emerging from the cottage industry phase of development. Most activity is restricted to particular units or modules of education and training and most are tightly bound within the emerging learning management systems, or loosely bound in a Web-based environment. Systems interoperability is low, costs of development are high and the learning experience offered to customers is of varying quality.

IMS GLOBAL LEARNING CONSORTIUM

It is instructive to explore the history of the IMS Global Learning Consortium (IMS)⁽¹⁾ in terms of systems interoperability for online learning environments because it is a most interesting case study in terms of how to develop both conceptual and practical views of interoperability requirements.

IMS began life in 1997 as the Instructional Management Systems Consortium, being an alliance predominantly of large systems vendors who began to see the possibility of a market in the online learning and training field. The main players included Microsoft, Oracle, Sun, PeopleSoft and SCT Banner; in other words it was an alliance between large-scale systems vendors who were primarily interested in selling enterprise systems into higher education and training environments.

The consortium started out with a determination to map the emerging online education and training environments at a high conceptual level with a view to developing comprehensive systems architectures. It rapidly became clear that this approach would not succeed because of inadequate understanding of the multiple service contexts, a lack of any agreed conceptual framework, confusion about semantics and no clear view of the size or extent of the so-called “learning space”.

The IMS Consortium then revised its basic strategies and decided to adopt a much more disciplined approach in terms of systems definition and development goals. In essence, the systems development centred around the relationship between student information systems and learning management systems (the latter players being principally Blackboard and WebCT). The approach taken was very systems-oriented and the planned specifications were limited in scope but achievable in tight time scales. Interoperability in this context had a defined “space” and agreed goals, which brought clarity of purpose, and it was the catalyst for a series of specifications which brought IMS to the attention of the global online learning and training communities.

CONSOLIDATION OF THE IMS GLOBAL LEARNING CONSORTIUM

With hindsight, the success of IMS owes a great deal to the support of the Advanced Distributed Learning Network (ADL)⁽²⁾, which is primarily sponsored by the US Department of Defense. Whilst the term learning appears prominently in the title of this initiative, the main objective of ADL is to develop online training for a complex range of activities supporting defence activities. Of great importance has been the emergence of SCORM (Sharable Content Object Reference Model), which has become the main testbed for IMS specifications. The alliance between IMS and SCORM has underpinned both the conceptual and practical development of specifications. It only gradually emerged, however, that SCORM is principally a training architecture, which is not entirely extensible to the online learning environments in higher education.

This has led to a strategic alliance between IMS and the Open Knowledge Initiative (OKI)⁽³⁾ in order to define and develop an appropriate systems learning architecture for higher education. OKI is an alliance between a number of the largest US universities, including MIT, Stanford, Harvard, Dartmouth, University of Pennsylvania and North Carolina State, backed by Carnegie Mellon funds. The aim of OKI is to define and build the next generation of learning management systems, the implication being that these new systems would be much more attuned to the complexities of learning experiences in higher education. This is an important step in the task of defining interoperability requirements for online learning environments. It also means that there will be at least two high level architectures, one for training and one for higher education. Plans are now underway, led from Australia, to explore the feasibility of developing a K-12 learning architecture, which could be applied in the global arena. It may well be that there are other appropriate high level architectures relevant to online education and training environments, but this seems unlikely in the near future.

SYSTEMS COMPONENT FRAMEWORK

Having established that there may be at least three high level systems architectures for education and training, there is now considerable attention being devoted to the question of developing a conceptual model to contain these major system architectures, given that there is inevitably much overlap between them.

The concept of a systems component framework has been actively canvassed as a means of accommodating multiple architectures. The initial debate on this conceptual challenge has been particularly interesting, because it marks a turning point where the learning experience becomes more central to defining the learning space and the service layers within the space. The work being done by Dan Rehak⁽⁴⁾ at Carnegie Mellon has been a catalyst for the ongoing debate, and he is developing a three level service stack model based on infrastructure, learning services and user agents.

CONVERGENCE OF LEARNING AND INFORMATION ENVIRONMENTS

In completing this overview of the evolution of IMS, it is necessary to take account of the multiple players now contributing to IMS, all of them seeking to find a market in the online learning and training environments.

Systems vendors are now outnumbered by learning content producers, educational designers, and commercial information providers resulting in an extended vision of interoperability. There are, however, considerable challenges in terms of redefining the service contexts and systems requirements, particularly given the convergence of the online learning and information environments. Those representing the information environment, principally librarians and commercial information providers, come with a long tradition of systems interoperability which does not yet fit easily with the online learning community, because of differing “world-views” of interoperability. The formation of the IMS Digital Repositories Working Group in late 2000 marks the formal alliance of the learning and information communities and some of the complexities of this “meeting-of-minds” will be explored in a more practical context in the remainder of this paper. The stage is set, however, for IMS to make considerable progress at both the conceptual and practical level over the next year, and input from learning and information communities from different countries is vital to the health of this process.

DIGITAL REPOSITORIES WORKING GROUP

The Digital Repositories Working Group came into being at the IMS Technical Board Meeting in Dallas in February 2000. The actual name of the Working Group does not do justice to the complex range of issues inherent in the defined “problem-space”. There were several strands of thought leading to the formation of the Working Group, which can be summarised as follows:

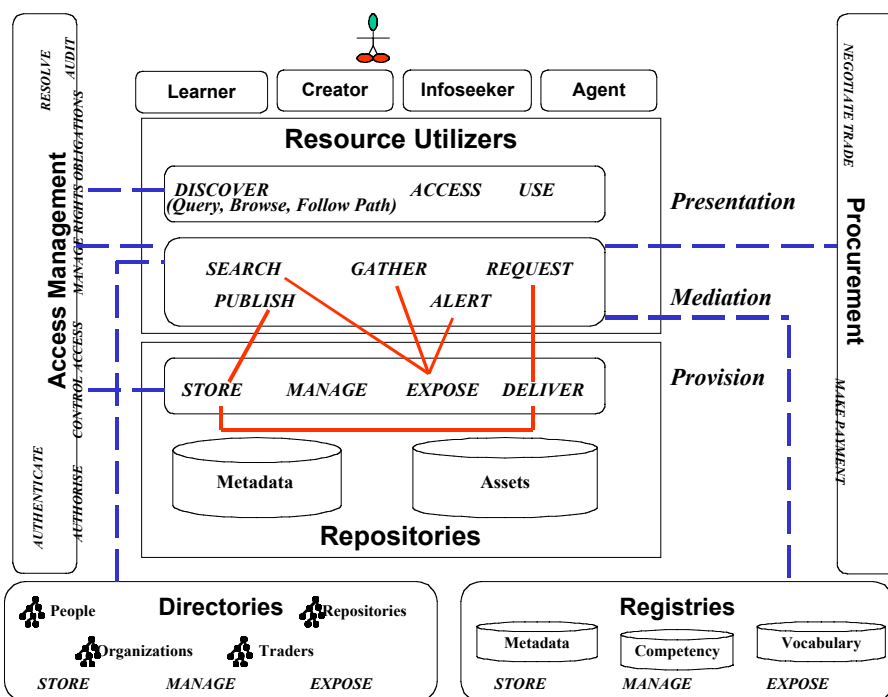
- a feeling that content could no longer be tightly bound in traditional learning management systems;
- the emergence of “learning object” repositories;
- the development of library-type digital repositories, most commonly known as “e-reserves”;

- the need to link a wide range of information domains to the online learning environment;
- the evident lack of any coherent form of interoperability between any of these repositories and between the repositories and the learning management systems.

The initial meetings of the Working Group were most challenging and the search for common ground in terms of scoping the work showed that there are many views of interoperability and very different perceptions of technical architectures. The Working Group has made considerable progress, however, through developing a White Paper⁽⁵⁾ and a Scope Document⁽⁶⁾ which map out the territory to be explored.

3.3 PROBLEM SPACE REPRESENTATION

A high level representation of the Digital Repository Problem Space is given in Figure 1. This figure represents a functional view of Digital Repositories and, in this context, the interactions



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necessary to support the key use scenarios described in the White Paper.

Figure 1 – Functional Architecture.

The diagram maps out three entity types defining the space where e-learning, Digital Repositories and Information Services interact, and provides a context for the exploration of the problem space. This is a *functional* view and does not represent an implementation architecture. The four entities are:-

- Roles (e.g., learner, creator, infoseeker, agent)
- Functional components for resource utilizers, repositories, access management and procurement
- Services (e.g., registries, directories)

A repository, as understood by this Working Group, is any system that facilitates the provision of assets to the external world. Repositories may hold actual assets or the metadata that describes assets. The assets and their metadata do not need to be held in the same repository.

Resource utilisers are any systems or system components that interact with these repositories – these could be a content creation system, a learning management system (LMS), an information gateway, etc.

Repositories may deliver assets to the resource utilisers at the time of discovery, for either one-off use and presentation to the user, or for inclusion in another repository as a copy of the original asset or as a component of a new asset. In this way discovered objects may be repurposed and reutilised.

The actual scope of work to be covered in Phase 1 is necessarily limited, but there is now a solid foundation for activity over the next two years.

BUILDING BLOCKS FOR INTEROPERABILITY

The remainder of this paper looks at a number of areas which can be best described as “building blocks for interoperability” in the context of the Digital Repositories Working Group activities.

They are dealt with in no particular order of importance, nor in any particular logical order. It is not the intention to deal with any of these areas in depth within the scope of this paper, although all deserve more extensive exploration and debate.

METADATA

There is a cluster of issues surrounding the application of metadata in the converged online learning and information context. A vast literature has emerged over the past three years on metadata and there is now a complex array of organisations, agencies and umbrella groups grappling with the implications of deploying metadata schemas. In the online learning environment the confusion can be best illustrated by the apparent battle between two competing standards, the Dublin Core Metadata Initiative (DCMI) and the IEEE Learning Object Metadata Standard (LOM). The overwhelming, but ultimately flawed, desire to adopt a single metadata schema for the online learning and information environment is at the heart of the problem and the meeting convened by Neil McLean in Ottawa in August 2001 between representatives of DCMI, IEEE and IMS was designed to reach an accommodation of views which could provide guidance to educational communities in terms of developing metadata initiatives.

The following program of action was agreed and disseminated as the Ottawa Communiqué⁽⁷⁾:

1. Develop and promote a set of fundamental principles for the development and application of modular interoperable metadata for dissemination to the global education and training communities
2. Develop a set of examples that illustrates how metadata should be generated in a given application profile, involving both DCMI and LOM metadata
3. Develop a set of guidelines and principles for the creation of application profiles involving both LOM and DCMI metadata

4. Develop an example of an application profile in the form of a machine readable compound schema

Other issues for potential collaboration include:

- (i) The development of maintenance registries
- (ii) An assessment of the degree of semantic drift that may have developed in the LOM interpretation of DCMI terms

This action program will not be achieved without difficulty, because it requires a lot of work by a small group of busy people dispersed across several countries. It is encouraging, however, that there are now signs of concerted agreement on these difficult issues.

In the wider context the metadata debate continues unabated. The underlying issues can be summarised in the form:

- a fundamental lack of understanding of the difference between using metadata for the purpose of discovery within and across service domains and the use of metadata in business applications, such as content management systems or learning management systems;
- confusion over the distinction between a standard and an application profile;
- an obscure (to most) debate about the use of XML as against RDF bindings;
- a misunderstanding of the role of the Open Archives Initiative Protocol ⁽⁸⁾ which only allows metadata to be harvested and does not provide for native searching of a repository;

- a lack of knowledge of how content management systems can handle multiple metadata schema;
- no firm appreciation of the role of controlled vocabulary and thesauri;
- uncertainty about the role of common search protocols such as Z39.50, as against emerging Web-based search protocols;
- a second-guessing of new technologies as a means of addressing the complexities of cross domain distributed searching;
- no clear idea of how searches based on exposed metadata translate into actual delivery of information or learning objects.

This imposing list of “unknowns” is not meant to send negative signals, but rather to highlight the breadth and complexity of the metadata challenges.

LEARNING OBJECTS

Perhaps the most confusing area in the emerging online learning environments is that pertaining to the term “learning objects”. It is now widely applied in the debates about metadata in the development of repositories and in the context of learning content management systems. The semantic confusion is not easily resolvable and the term “learning object” probably needs to be deconstructed and placed in more defined operational or service contexts.

The most succinct summary of the present situation appears in a recent summary by Bryan Chapman and Brandon Hall⁽⁹⁾. They state:

“A learning object is not really a set technology; rather it is a philosophy for how content can be created and deployed. There are no current standards for what constitutes an exact learning

object although some (companies) have provided simplistic models for learning object design The SCORM specification probably comes the closest to defining learning objects by providing standards for tagging learning content and methods for storing course hierarchy (see <http://www.adlnet.org> for more information).

A higher level, but more accurate description of a learning object, is a granular learning topic, anywhere from five to 15 minutes in length that can be reused with all of its associated relationships, which may include links to objectives, competencies, test questions, associated properties and metadata tags. However we also discovered that in some LCMS learning object models even an individual tagged media object could be considered a learning object”.

This brief summary illustrates the inherent complexities of the learning object field and there is a need for much more conceptual and practical definition, particularly in the context of the Digital Repositories Working Group.

LEARNING CONTENT MANAGEMENT SYSTEMS ~ LEARNING MANAGEMENT SYSTEMS

Most online learning and training environments demand new forms of systems platforms to deliver content and to manage the actual learning or training experience. Learning management systems such as WebCT and Blackboard have widespread application in the higher education sector across the US, Europe and Australia. Whilst the primary purpose of learning management systems is to manage learners and to keep track of their progress and performance in the learning program, they have been used to store content and to act like content management systems. Courses are therefore, tightly bound, costly to revise and very inflexible from the learner viewpoint.

Over the past few years learning content management systems (LCMS) have emerged serving a somewhat different purpose i.e. to provide a multi-developer environment where developers can

create, store, reuse and deliver learning content from a central repository. As Chapman and Hall⁽⁹⁾ state:

“An LCMS will generally have a majority of the following characteristics:

- Based on a learning object model.
- Content is reusable across courses, curricula or across the entire enterprise.
- Content is not tightly bound to a specific template and can be re-deployed in a variety of formats such as e-Learning, CD-ROM, print-based learning, PALM, EPSS, etc.
- Navigational controls are not hard coded at the content (or page) level.
- There is a complete separation of content and presentation logic.
- Content is stored in a central database repository.
- Content can be represented as XML or is stored as XML.
- Content can be tagged for advanced searchability (both at the media and the topic level).
- Pre-tests and post-tests can be automatically aggregated from test questions written for the primary instruction. In addition, the system can deliver the test and prescribe learning based on performance.
- The system manages the development process by providing some level of workflow tools to manage a multi-developer, team environment.
- Version controls and archiving capabilities to store previous versions of content.
- Advanced searching capabilities across all objects in the repository.
- Interoperability with third-party learning management systems.
- Includes a delivery engine for serving up content, automatically adapting to user or group profiles, adding navigation controls, collaboration tools, utilities, and look and feel (skins).

Whilst these learning content management systems draw on a central repository, it is obvious that this type of digital repository has many different characteristics to the type of digital repositories deployed in the information-object type environments. The IMS community is,

therefore, still coming to terms with the interoperability issues that emerge in attempting to link an LCMS to other types of information repositories and to learning management systems.

AUTHENTICATION, AUTHORISATION AND DIRECTORY SERVICES

Online learning and information environments are nearly always distributed services environments. This means that learners may be taking courses in more than one institution and that they will be accessing a complex array of services across domains. There is a need, therefore, for highly sophisticated infrastructure to deal with the authentication of learners and the multiple levels of authorisation inherent in any particular learning experience service cycle. Effective authentication and authorisation protocols are, in turn, dependent on the deployment of directory services which, in effect, “manage-the-traffic”.

Over the past five years a great deal has been written about authentication and authorisation, but effective solutions have proved elusive. It is significant that most service stakeholders in the higher education environment generally assume that it is “someone-else’s-problem-to-solve”. It is significant also that the IMS Digital Repositories Working Group acknowledge the importance of authentication and authorisation but has been careful to put it outside scope for Phase 1 and probably for Phase 2 of development work.

The principal problem continues to be the lack of conceptual and practical understanding of how to match people and resources using schema based on directory services. There is also a lack of understanding of the type of directory services required to sustain a distributed services environment. As Alan Lloyd⁽¹⁰⁾ states:

“There are basically three types of application of directory services:

- Those for the enterprise which are office automation type systems;
- LDAP servers for small scale non-distributed environments; and

- Large scale LDAP accessed X.500 systems where different name spaces exist in different servers that are interconnected to form a seamless high capacity distributed system.”

It seems inescapable that a truly interoperable online learning environment will demand the application of large scale X.500-based systems. X.500 is a distributed secure directory service that defines standard business objects and attributes with protocols to access and interconnect these objects. There is still no concerted attempt in the education communities to address this need for large scale distributed directory services because institutional priorities generally come first and there are many directory service applications that deal reasonably well with single institutions.

There is also a persistent belief in the market place that LDAP directory services will fulfil all the authentication and authorisation requirements. LDAP is the protocol between directory server or service used. An LDAP server by definition does not deal with distributed interconnected servers and a distributed namespace and Lloyd⁽¹⁰⁾ estimates that LDAP server functionality has about 20% - 30% of a real LDAP accessed X.500 system.

Directory services are the key to interoperability and it is somewhat depressing that there is so little attention being paid to their application in the learning and information space.

DIGITAL RIGHTS MANAGEMENT

Digital rights management (DRM) has emerged over the past year as one of the most pressing technical challenges to be solved in the online learning and information environments. DRM is, in essence, a complex form of digital asset management and cannot, therefore, be simply “bolted-on” to existing systems.

It has proved to be a very difficult area to understand because there are few precedents on which to build conceptual or practical service models. At its most abstract level it can be regarded as

the key to electronic trade of digital objects, however, it is likely that the implementation scenarios will be incremental in nature.

As stated in the overview of the proposal for an Open Digital Rights Language (ODRL)⁽¹¹⁾:

"Digital Rights Management (DRM) involves the description, layering, analysis, valuation, trading and monitoring of the rights over an enterprise's assets; both in physical and digital form; and of tangible and intangible value..... At all stages, the Rights need to be managed and honoured with trusted services".

It is likely that DRM will become an IMS work item associated with the Digital Repositories Working Group, as there is considerable work being done in Australia in conjunction with OKI, based at MIT.

The first stage is to assess the business requirements of the various sectors and to produce use scenarios that lend themselves to systems analysis. There will be no quick solutions, because DRM has to be incorporated into service cycles, which almost certainly will involve multiple systems vendors and a great deal of experimentation.

PORTALS

Portals have now been a "buzzword" for some years and the term has become a label for a wide range of technical initiatives aimed at providing a seamless interface for users. The claims and counter-claims of systems and service vendors in the portal space are bewildering and there is a need to have a reappraisal of some of the underlying issues. The following observations are relevant to any such reappraisal:

- The fundamental distinction between searching for the known, as against the unknown, needs to be borne in mind constantly in the planning and evaluation stages;
- There is a basic difference between "window-shopping" and being able to "buy-what-you-see";

- Most applications, by definition, will have a task-focussed portal to assist users;
- Most task-focussed portals have the ability to cover some but not all of the wider service spectrum portal space;
- The underlying portal technology ultimately depends on the use of directory services to match people and resources;
- The weaving of task-focussed portals into a single presentation layer for the user is a desirable goal;
- Cross domain discovery still presents enormous challenges to the portal concept;
- The effectiveness of portals is inextricably linked to the application of metadata schemas;
- Users will continue to use multiple portals.

Some would argue that the marketplace will “sort-out” the portal space. On the other hand the lack of a proper conceptual grasp of the implications of portal applications within the online learning and information communities, probably means that the market driven approach will remain fragmented and limited in terms of scope. It is probably true also that some of the more ambitious portal projects funded with public money will also be doomed to failure.

LEARNING SPACE INTEGRATION

Having explored the underlying dynamics of interoperability in the online learning and information environment, it would be easy to conclude that it is “all-too-hard”. There is no doubt that the Digital Repositories Working Group has been struggling to contain the conceptual and technological “drift” that naturally occurs when addressing such a complex service environment. There is no easy way of addressing these issues in a practical sense, but projects are required to explore learning space integration. In the Australian context, it is likely that a number of companies will come together under the IMS umbrella to address the problems of integrated user profiling i.e. drawing on data from multiple applications and allowing seamless movement between application portals and to incorporate digital rights management infrastructure into the application environment.

In seeking partners, it is likely that the following “chunks” will be represented in the project: a learning management system, a learning content management system, a library-type system, a provider of DRM technology, and a directory systems vendor.

From the “chunks” perspective the proposed learning space can be depicted as in Figure 2.

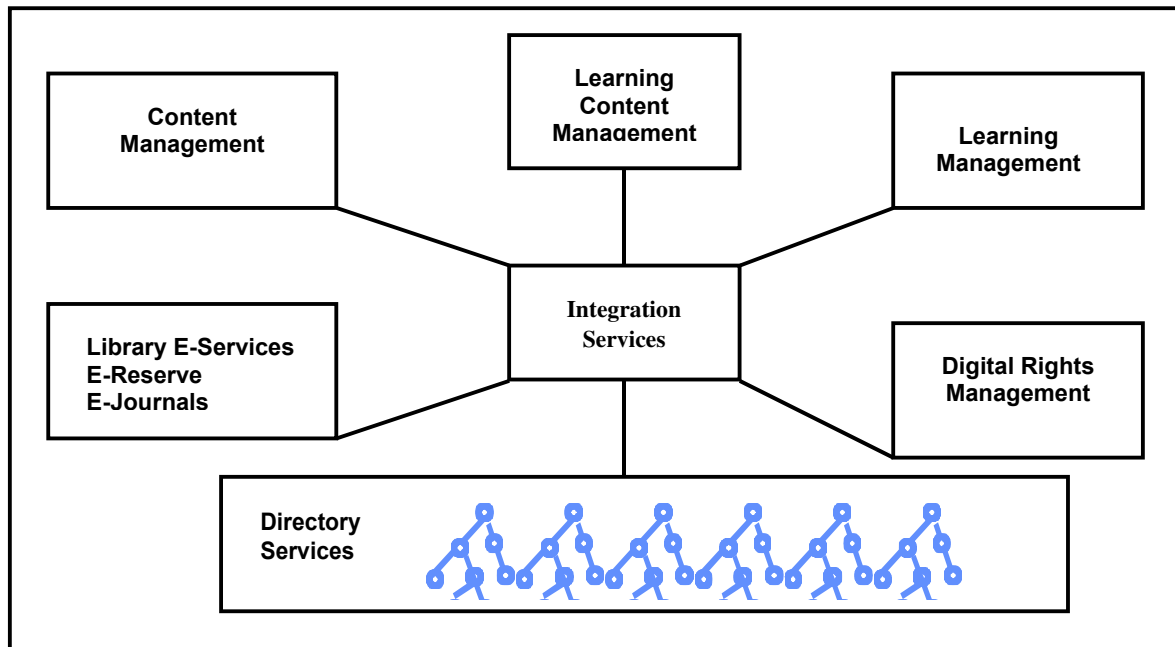
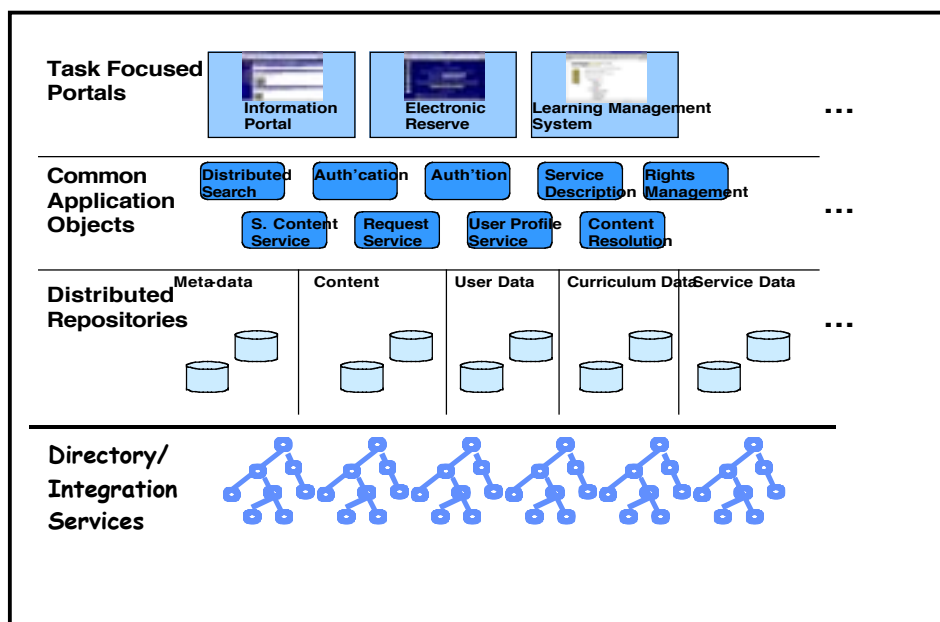


Figure 2 Learning Space “Chunks”

From the service layer perspective, the proposed learning space application integration can be depicted as in Figure 3.



CONCLUSION

This paper has attempted to provide a “snapshot” of the interoperability issues facing the converged online learning and information domains, primarily from an IMS perspective. For the past decade each of these domains has been working towards their own particular view of the information landscape, the standards agenda and the semantics that surround the technical and business issues.

The political, conceptual and technical challenges in achieving a convergence between the online learning and information communities remain formidable but the foundations are now being laid to build a consensus on the “big” issues.

It remains to be seen over the next five years as to how the converged learning and information application space will unfold and the most critical success factor is likely to be the creation of international mechanisms to accommodate the coherent exchange and development of technical interoperability agendas.

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