Interoperability Specifications for E-learning

This section describes why we need standards and specifications to support e-learning, what the standards are and how they are described.

1.1 Why have specifications and standards

E-learning has been being developed for over 40 years, and in that time has advanced considerably, as has the hardware and software on which e-learning tools run. Historically we have seen e-learning packages and tools developed for particular systems and as they have become obsolete the tools and resources have been lost. Examples of this abound, and we will describe just two.

In the 1970s a huge resource was developed for schools in the UK called the Doomsday Project which made use of laser discs and the BBC Microcomputer. Children from around the country collected information and pictures about their locality and this was then published. Now, it is almost impossible to find a BBC Micro in use or a laserdisc with the result that this entire project has been lost.

In the 1980s and early 1990s the higher education funding councils in the UK funded a huge programme , the Teaching and Learning Technology Programme (TLTP)

[HEFCE99] which cost over €60m ecu to develop e-learning resources for use in higher education. Nearly 100 projects were funded which each developed e-learning software. However, they were funded just before the web became a popular medium and many of the products were developed using tools like Toolbook. This has meant that very few of the products developed are still in use.

Over the last five or so years there has been a growing realisation that the rate of change in communications and information technology will not slow down over the foreseeable future, and that with the increasing investment in the development of resource to support learning there is a need to develop ways of ensuring the best possible return on that investment.

This has lead to the growing importance of learning technology standards, in the expectation that this will make it more likely that learning products will continue to be useable even as the underlying technology changes.

There has also been a huge growth in the use of virtual learning environments (VLE) (also known as learning management systems), and developers of these systems want to be able to provide access to as much content as possible whatever its source. Similarly content developers want their content to work in as many VLEs as possible in order to maximise the size of the market that they are developing for.

These forces have led both vendors and customers to realise the increasing importance of using standards and specifications in their implementations, although as discussed in section 3, Adoption of Specification-Based E-learning, there are considerable problems with the usage of open standards and specifications, including a lack of clarity of the differences between specifications and standards, and these are discussed here.

1.2 Specifications and Standards

There is a need to be clear about the differences between standards and specifications and their relative roles. Both have an important role to play in helping to develop a dynamic market in educational technology in general and in particular in achieving interoperability of content and interoperability between systems from different vendors.

The primary difference between standards and specifications is that standards have some legal authority as they are produced either by the International Standards Organisation (ISO) or by one of the national bodies such as DIN or BSI, or by a body which is working with one of the standards organisations (such as the IEEE or the CEN/ISSS). By contrast, anyone can produce a specification and its authority comes solely from the degree of acceptance it achieves within the community.

Standards bodies are essentially NGOs, set up under international treaty which regulate how they work and how standards are produced. The procedures are designed to achieve consensus amongst all interested parties and to produce standards which will remain in force for extended periods. They can cover anything from the voltage for mains supply and the shape of a socket to quality assurance procedures and metadata for learning objects.

However, because a consensus is required it can take considerable time to agree a standard, with seven years from a standard initially being proposed to its eventual acceptance as a formal standard not being uncommon. While this is perfectly satisfactory in many cases (we do no want frequent changes in the shape of electric sockets) it is inappropriate for a fast moving field such as communications and information technology. There are very few areas in C&IT where these sorts of development times are appropriate, and therefore alternative solutions are required to obtain agreements between all the interested parties, and this is where specifications can be useful.

As has already been stated standards can only be produced by organisations which have the legal power to do so, however anyone can produce a specification and this includes individual companies, industry groups and specially set up organisations. This means that there are no set procedures for defining a specification. For instance, a company can choose to publish a specification and then leave it up to others to either use it or not (Microsoft with .net, or Sun with Java for instance). In this case the specification may continue to be owned by the original publisher, or it may be released to the community through some form of third party organisations such as a standards or specifications body, in which case the creator may try to retain some control over it.

1.3 Specification and Standards developers

The IEEE is the main standards body working on e-learning, however a wide variety of bodies are working on specifications for e-learning and in related areas. Specifically in the field of e-learning standards the IEEE has been working with some of the specifications bodies (such as IMS and ADL) to develop the IEEE Learning Object Metadata (IEEE LOM). This primarily built on the work of IMS and ADL to produce the LOM, on which all parties could agree.   As can be seen in Table1: Table of specification organisations and the areas that they are working in. and "Table 2: Table of standards organisations and the areas that they are working in. there are several specification and standards bodies working on different parts of the field to produce standards.

There are several a variety of specification groups working on learning technologies. These address different audiences or different issues. The two most important are IMS which emerged out of US higher education but quickly got many of the vendors involved as well and has had significant international involvement almost from the start. The other major specifications body is ADL which is primarily concerned with the needs of the US military. It has produced SCORM. These groups work with each other wherever possible, and there is often strong cross-membership between the various groups, with many of the people active in IMS also being active in ADL, and many of those active in the DCMI community also active in the OAI community.

We will next look at who is working on standards and specifications in learning technology and which issues they are addressing for which communities. The tables below show which bodies are developing specifications and standards in which areas of e-learning. A very brief description of each of these areas is given below the tables, with a fuller description of the specifications that IMS is developing provided in Appendix B.

Area	**Specifications Organisation**						
	IMS	SIF	DCMI	AICC	HEKATE	OAI	W3C
Metadata	Yes		Yes				
Repository operations	Yes		Yes			Yes	

Content packaging	Yes						
Content sequencing	Yes						
Content runtime behaviour				Yes			
Assessment	Yes						
Student and course data	Yes	Yes					
Learner information	Yes	Yes					
Learner competencies	Yes						
Logistics		Yes					
Messaging / Web services		Yes			Yes		Yes
Accessible content	Yes		Yes				Yes
Accessibility preferences for learners	Yes						
Learning design	Yes						
Collaboration							
Learner support							

Table1: Table of specification organisations and the areas that they are working in.

Area	**Standards Organisation**			
	IEEE	BSI	ISO	CEN / ISSS
Metadata	Yes	Yes	Yes	Yes
Repository operations				
Content packaging	No (underway)			

Content sequencing				
Content runtime behaviour	No (underway)			
Assessment		Yes		
Student and course data				
Learner information	Yes	Yes	Yes	
Learner competencies	No (underway)			
Logistics				
Messaging / Web services				
Accessible content				
Accessibility preferences for learners				
Learning design				
Collaboration			Yes	
Learner support		Yes		

Table 2: Table of standards organisations and the areas that they are working in.

Organisation	**Full name**	**URL**
Specification Organisations		
IMS	IMS Global Learning Consortium, Inc.	http://www.imsglobal.org/
SIF	Schools Interoperability Framework	http://www.sifinfo.org/
DCMI	Dublin Core Metadata Initiative	http://dublincore.org/
AICC	Aviation Industry CBT Committee	http://www.aicc.org/
HEKATE	Higher Education Knowledge and Technology Exchange	http://www.hekate.org/
OAI	Open Archives Initiative	http://www.openarchives.org/
W3C	World Wide Web Consortium	http://www.w3.org/
Standards Organisations		
IEEE	Institute of Electrical and Electronics Engineers	http://www.ieee.org/

BSI	British Standards	http://www.bsi-global.com/
ISO	International Organization for Standardization	http://www.iso.org/
CEN/ISSS	European Committee for Standardization / Information Society Standardization System	http://www.cenorm.be/isss/

Table 3: Specification and Standards Organisations

- **Metadata** – is data about data, it is used to describe and locate information, learning objects and services.
- **Repository operations –** a repository is essentially a database used to hold objects of some sort and the metadata that describes them. This includes the ability of users to search the repository and retrieve the objects within it. Within e-learning they are often learning object repositories.
- **Content packaging –** is an IMS specification to enable learning objects to be moved from one virtual learning environment to another in such a way that the sub-objects are available in the same way in all VLEs.
- **Content sequencing -** describe navigation paths through a collection of learning activities. The IMS Simple Sequencing specification restricts itself to the case of a single user in the role of learner and to a limited number of ways to control sequencing.
- **Content runtime behaviour –** this specifies the type of information that a module can store and retrieve from a VLE so that users can return to learning objects that they have not completed.
- **Assessment –** this describes questions, question types, the correct answers (and in the case of multiple choice some wrong answers) and any scores and feedback to be provided.
- **Student and course data** – this describes information about courses and students, including which courses they are enrolled on and the results of the course.
- **Learner information** – describes information about the learner and their preferences which can be used by VLEs and learning objects to customise the learning experience to the user's needs
- **Learner competencies** – describes competencies relating to students or to units of learning, used for personal development planning and personal development records.
- **Logistics** – this is concerned with the management of physical resources at educational establishments. It can include timetabling and transportation and even catering.
- **Messaging / Web services** – this is a lower level messaging service that some of the educational technology bodies are involved with.
- **Accessible content** – describes the accessibility of the learning materials to ensure that it is as accessible as possible to the widest possible range of learners. Includes guidance and good practice.
- **Accessibility preferences for learners** – closely related to learner information, it specifically describes their accessibility preferences.
- **Learning design** – It is used to describe and implement learning activities based on different pedagogies, including group work and collaborative learning, and can be used to coordinate multiple learners and multiple roles within a multi-learner model as well as supporting single learner activities, and coordinate the use of learning content with collaborative services.

- **Collaboration** - used to describe collaborative and multi-learner activities.
- **Learner support** – this code of practice is concerned with specifying the way in which assistance is provided to the learner, including help systems.

Beyond this there are a number of other groups that are also developing specifications that relate to the e-learning world. It is worth briefly describing each of these bodies and what they are doing, starting with IEEE as the standards organisation.

1.3.1 Institute of Electrical and Electronics Engineers (IEEE)

The IEEE is a non-profit, technical professional association of more than 360,000 individual members in approximately 175 countries, which has 900 active standards and 700 under development covering all areas of Electrical and Electronics Engineering. Through the Learning Technology Standards Committee (LTSC) the IEEE is currently working on an architectural reference model [IEE01]as shown in Figure 1 The Learning Technology SystemsArchitecture (LTSA) abstraction-implementation layers., and Figure 2 The LTSA system components. They have already produced the IEEE Learning Object Metadata Standard (LOM) [IEEE02] and are working on several other standards.

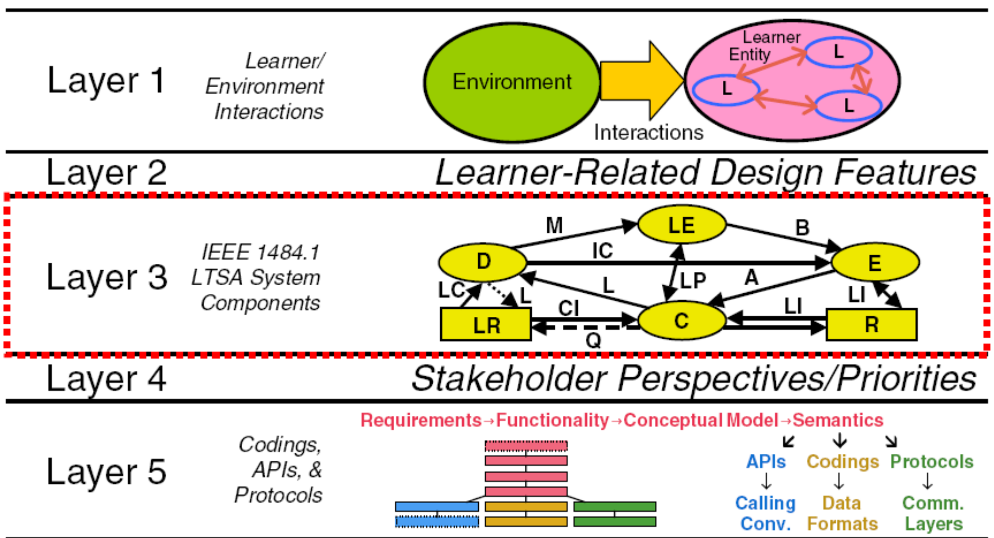

Figure 1 The Learning Technology SystemsArchitecture (LTSA) abstraction-implementation layers. [from IEEE01]

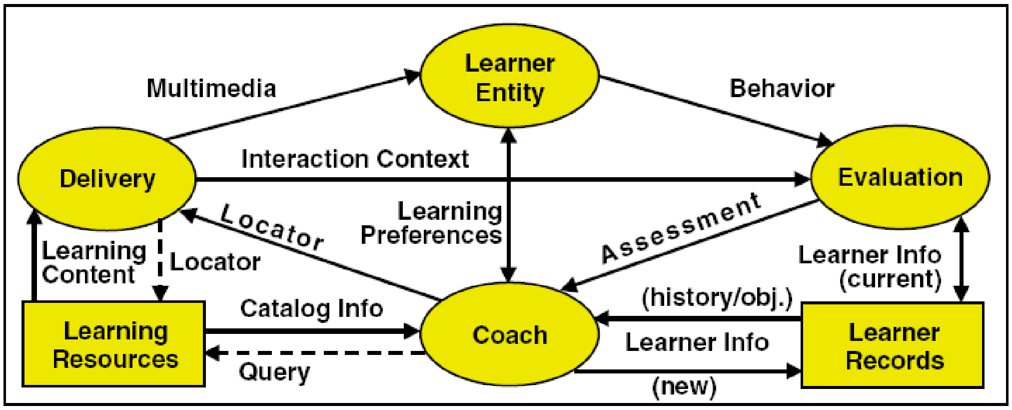

Figure 2 The LTSA system components. [from IEEE01]

1.3.2 IMS

IMS was originally set up in 1997 by Educause (the association for IT directors in higher education in the US) to define learning technology specifications, with an initial focus on higher education it has expanded to cover further education, schools and training as well.

Like IEEE its first venture in the field was with metadata specifications, with the first version being produced in 1990. It is now active across much of the scope of education including management of learning (enterprise specification) and learning (learning design). It too has developed a layered architecture, which is discussed below.

1.3.3 Advanced Distributed Learning (ADL)

The Advanced Distributed Learning (ADL) Initiative, sponsored by the Office of the Secretary of Defense (OSD) in the United States, is a collaborative effort between government, industry and academia to establish a new distributed learning environment that permits the interoperability of learning tools and course content on a global scale. ADL's vision is to provide access to the highest quality education and training, tailored to individual needs, delivered cost-effectively anywhere and anytime.

ADL have produced the Sharable Content Object Reference Model (SCORM), which is now mandated by the Department of Defense in the US for their e-learning, and is widely used elsewhere; including notably by UfI as the basis of their application profile.

SCORM is a collection of specifications and standards that can be viewed as separate "books" gathered together into a growing library. Nearly all of the specifications and guidelines are taken from other organizations. These technical "books" are presently grouped under three main topics: "Content Aggregation Model (CAM)," "Run-Time Environment (RTE)" and "Sequencing and Navigation (SN) (introduced in SCORM 2004)." Additional specifications are anticipated in future SCORM releases. SCORM differs from most of the other specifications in that it included behaviours as well as data; by defining an API. ADL have also produced a conformance test suite for SCORM.

The SCORM works by firstly defining the way Sharable Content Object (SCOs) should be authored and secondly how SCOs should behave within a VLE. The reference model has two corresponding parts: a content aggregation model and a run-time environment. Content aggregation is the process of creating, describing and packaging SCOs into a course structure and Run-time behaviour is the process of launching a SCO from within a VLE and then tracking the learner's activity with the SCO.

Run-time behaviour is managed by the SCORM run-time environment. A key feature of this environment is the ability of a SCO to communicate with a VLE. This feature is provided by a small piece of software provided by the VLE and named an API Adapter. API Adapters are provided by the VLE. When a learner requests a SCO, the SCO searches the VLE to find the API Adapter. Once found, the SCO initiates communication with the VLE via the API Adapter. The communication between the SCO and the VLE is used to track and store records of learner activity. Communication between the SCO and the VLE uses three types of run time commands: execution state commands, data transfer commands and state management commands.

1.3.4 Human Resources XMl (HR-XML) Consortium

The HR-XML Consortium is an independent, non-profit organization dedicated to the development and promotion of a standard suite of XML specifications to enable e-business and the automation of human resources-related data exchanges. Human resources-related e-business — or any inter-company exchange of HR data — requires an agreement among participants about how the transaction or data exchange will be accomplished.

The HR-XML consortium has produced about 30 specifications, of which the following have some relevance for e-learning and are defined in Appendix B.

- Assessments,
- Competencies,
- Education History,
- Resume,

Some of the others may need to be understood if data is being passed between places of learning and employers (eg. Person Name and Person Address).

1.3.5 The Open Knowledge Initiative (OKI)

The Open Knowledge Initiative (OKI) [OKI started at MIT in 2001 with funding from the Andrew W. Mellon Foundation to develop:

- A set of Service Interface Definitions that specify interactions between modules, programs, and systems within and across institutions.
- Open source code for a reference implementation of each service, with documentation of the architectural assumptions that underlie the Service Interface Definition.
- Open source code for two production learning management systems — Stellar, developed at MIT, and CourseWork, developed at Stanford University.

While OKI is not a standards or specification body it is defining an open architecture for e-learning, and is working closely with ADL, IMS and others. It has produced a set of Open Service Interface Definitions (OSID), and these are described in Appendix B.

1.3.6 Schools Interoperability Framework (SIF)

The Schools Interoperability Framework (SIF) is a non-profit membership organization comprised of over 100 software vendors, school districts, state departments of education and other organizations active in primary and secondary (K-12) markets, who have come together to create a set of rules and definitions to enable software programs from different companies to share information. This set of platform independent, vendor neutral rules and definitions is called the "SIF Implementation Specification." It covers a wide range of topics that support education including catering as well as more directly educational issues such as grade books. See Appendix B for further details.

1.4 Describing a Specification

Specifications are normally described in two parts, a human readable form and a more formal specification which could be in XML, UML or some other machine readable language. In the case of IMS these are referred to as the Information Model and XML Binding Specification, with the latter described in the next section.

The information model should, as far as possible, be written independently of any possible implementation, so that the specification can be expressed using any appropriate binding. However, the human readable form of the specification has a number of problems inherent within it. The foremost of these is the ambiguous nature of human language. The concept behind specifications is that they should assist with the interoperability of systems. Where a specification is open to a variety of interpretations Sod's Law means that implementers will interpret the specification in mutually incompatible ways, hence the need for the more formal definition. Even then there is often scope for multiple interpretations and thus the need to keep specifications under review.

The main function of the information model is to assist the user of the specification to understand the more formal definition provided by the bindings; typically the information model will include the following:

1.4.1 Objective of the specification

This is a brief description of the function of the specification to provide the user with a broad understanding of the specification.

1.4.2 Requirements

This describes the user requirements that the specification is designed to meet, and should make clear what the specification is designed to cover and the full scope of this. It may also specify some of the (related) requirements that it is not covering, especially if these are addressed by other specifications, in which case these will be cross-referenced.

1.4.3 A conceptual model

This may be represented in a variety of ways. Early IMS specifications only used data tables, while more recently these have been supplemented by the use of UML diagrams. UML has the advantage of being a widely accepted model with a large number of tools to support it. A typical UML diagram (from Learning Design Specification) is shown below.

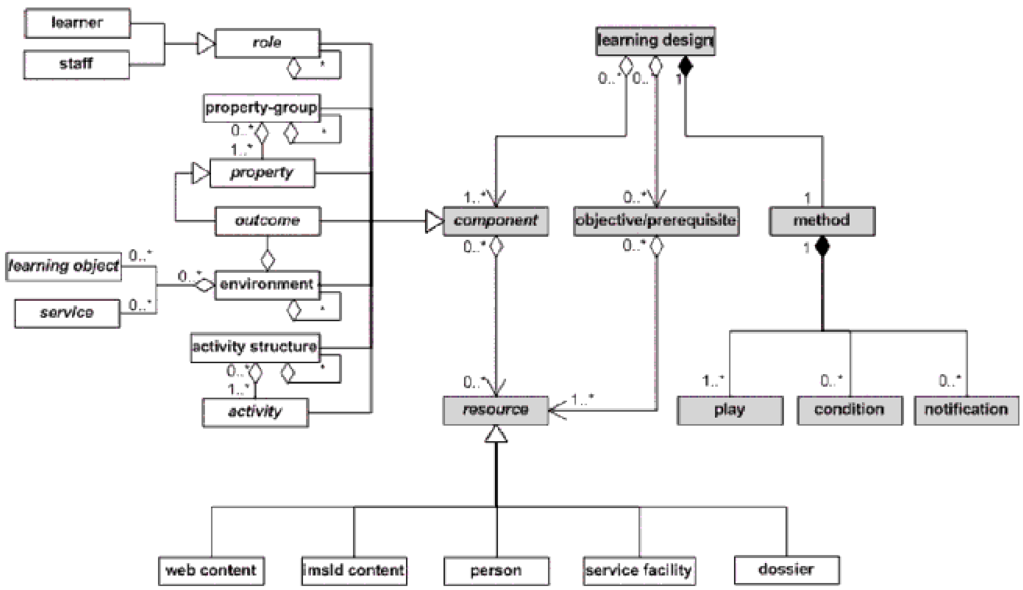

Figure 3: UML Diagram of the Learning Design Specification

The data tables describe each of the elements in the specification, with a brief explanation of its function, whether or not it is mandatory, how many instances of the item are allowed and the data type for that item.

1.5 XML-based Bindings

For the industry to achieve real working interoperability with specifications, it has been necessary to choose particular technologies that the specifications can be bound to. The key considerations for such binding technologies are that they are open in nature, allowing a wide range of computing platforms, programming languages, and toolsets to be used to create compliant applications and content.

XML, the eXtensible Markup Language, is a specification produced by the World Wide Web Consortium (W3C) for an open interchange technology for data. Based on SGML, an early markup language for large controlled documents such as technical manuals, XML works by providing users with the ability to mark text within a document using tags, just as in HTML and SGML. The difference is that XML is extensible, allowing users and communities to construct their own tags, effectively providing the ability to write new markup languages.

XML allows for the creation of documents that are to some extent self-describing in nature. For example, if we compare a “name”-type structure expressed first using a comma-separated list and an XML document, it is easier to ascertain the context and use of the data in the XML format, and interpret it correctly:

Wilson, Bradley, Scott

```
<name>
<family>Wilson</family>
  <first>Scott</first>
  <middle>Bradley</middle>
```

</name>

As well as making the data more readable, this allows developers to use the data to assist them in interpreting how it should be used. The downside of using XML is that the size of the data has increased substantially – the readability and openness of XML comes at the cost of efficiency.

As well as the XML documents themselves (known as “instances”), the W3C also developed specifications for creating “control documents” that are used to define the structure of XML documents themselves. These specifications – first Document Type Definition (DTD) and later XML Schema (XSD), allow parties to construct vocabularies of tags for particular types of documents, and to insist on particular structuring rules. Using a DTD or XSD allows a recipient of an XML instance to determine whether that instance conforms to the control document.

DTDs and XSDs also provide a means of expressing a specification in a machine-readable fashion, and have been the first step towards testing for the conformance of content and applications; testing the XML instances for conformance against control documents provides a certain level of syntactic analysis for conformance.

Unfortunately, DTDs, and even the much more sophisticated XML Schema, cannot sufficiently express all the constraints and requirements of a specification for conformance, and experience has shown within the e-learning community that XML instance conformance against a control document does not alone guarantee interoperability. This is a product of several factors: specifications provide some deliberate flexibility to allow community-specific modifications, specifications do not always take advantage of all the advanced features of XML schemas, and some types of constraint are simply not suited to expression by the W3C XML schema language itself.

As well as XML, XSD and DTD, the W3C has been developing other technologies based on XML for expressing behaviours as well as static documents. The Web Services Description Language (WSDL) is an XML-based specification for describing interfaces for services, while SOAP is a specification for using XML to transmit messages between services over a network. Using WSDL and SOAP it is possible for one application to use the services of another, even if they are operating on different platforms and written with different programming languages.

New elearning specifications are being developed to take advantage of the capabilities of WSDL and SOAP for interoperability.

There are a great deal more “web services” specifications both released and under development, providing various enhancements to the basic concept of exchanging XML instances over networks, such as added reliability, security, and choreography of messages.

1.6 E-learning Frameworks and Architectures

A Framework is an abstract description which allows for a shared understanding of the various systems and their interrelationships, in this case, in the field of e-learning. It is at a sufficiently high level that it allows for a description which is independent of the technologies which might be used to implement it. An architecture is a detailed instantiation of the framework, which meets the specific needs of an organisation that intends to implement it. The architecture may therefore include technology dependent details that conform to the needs of the institution implementing it.

The use of frameworks has a number of advantages:

1.6.1 Benefits to teachers and learners

1.6.1.1 Supporting pedagogic diversity

It becomes possible to support a very diverse set of learning models as it becomes feasible to configure the low-level elements of the learning architecture to fit a variety of pedagogic and institutional business models

1.6.1.2 Enabling pedagogy-driven implementations

By exposing modular processes as separate services, which can be configured in multiple ways, the construction of technology solutions can become driven by pedagogical imperatives, rather than the reverse.

1.6.2 Benefits to institutions

1.6.2.1 Providing better returns on technology investment

Applications can be developed or acquired as needed, which means that only those parts of the system that really need to be changed are replaced retaining the rest of the systems so reducing both purchasing and implementation costs, particularly in terms of staff development and training.

1.6.2.2 Enabling faster deployment of technology

As components are independent it will often be easier to deploy new components so long as the needs of the new components are compatible with the existing interfaces. Even where this is not the case it may still be simpler to alter or replace other components to supply the requirements of new systems.

1.6.2.3 Providing a modular and flexible technology base.

The rationale for the framework is specifically to enable the development of modular and flexible systems, where the individual components can be added or replaced more easily than in traditional models

1.6.2.4 Making collaboration between institutions easier

Through a common framework and thus a common service oriented architecture it becomes easier to define the application interfaces which are needed and thus to share information between institutions (for instance to support student progression). It may also make sharing of applications easier, as it will be simpler to define small applications which are needed in common and can be developed to meet the needs of each institution.

1.6.3 Service-level Abstractions

To make sense of the complexity of business processes, data storage, and application logic, there is a need to take the approach of condensing the focus of the framework to a set of services.

Each service encapsulates some form of process meaningful in the context of e-learning, which can be delivered by any number of actual software components.

Service-level abstractions correspond clearly to the notion of Web Services, with each service capable of being defined by using the Web Services Description

Language (WSDL). However, this is only one possible interpretation of a service, and services could be realised using a range of technologies.

The important point about services is that the framework is not concerned with either how a service is implemented, or the processes it is used in, but instead only with the set of defined interactions that a service supports. This functional focus allows us to be specific about the range of expected behaviours of an individual service, while remaining agnostic with regard to implementation technologies and overall architecture of particular solutions.

The advantage of defining the framework in this manner is that is possible to select services from a variety of suppliers so long as they define their interfaces in the same way. This is where the specifications and standards come in, by defining a neutral way to exchange data between services and by defining what the service does it becomes possible to ensure that services from the various sources will work together. However, this requires compliance testing to ensure that the services will do what they are supposed to.

1.6.4 The Layered Services Framework

As with other approaches to e-learning frameworks, the starting point is the abstraction of service layers. IMS in their framework identify four layers, and these are widely used in other frameworks as well.

- ***Applications*** (also known as user services) interact with users directly, such as portals, learning delivery systems, authoring tools, administration interfaces and so on. User Agents based on this framework can be either very small and focussed or span many processes to provide a coherent workflow.
- ***Application Services*** provide functionality required by user agents, such as retrieving learner information, or storing content in a repository. Application Services may be implemented so that they have some sort of user interface, but the key requirement for an application service is that it exposes its functionality for reuse by any number of user agents or other application services, and that it implements a standard interface to support this reuse
- ***Common Services*** provide lower-level functionality which is not education-specific, such as authentication and authorization services, but upon which application services and user agents depend.
- ***Infrastructure*** is the underlying network, storage, and processing capability provided for an implementation. This is assumed by the framework, but not defined.

Below is shown the IMS abstract framework [IMS03] and then below a figure showing how the framework can be extended in a local context, in this case that of UK further and higher education [WIL04]

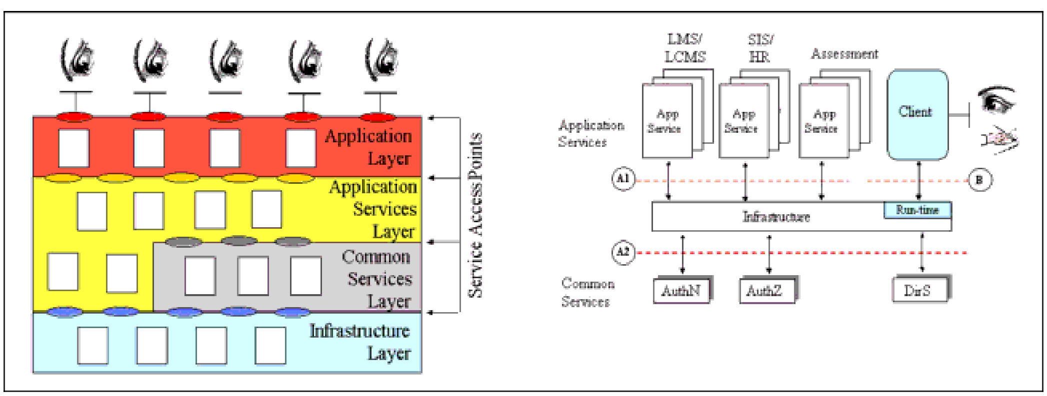

Figure 4 IMS Abstract Framework

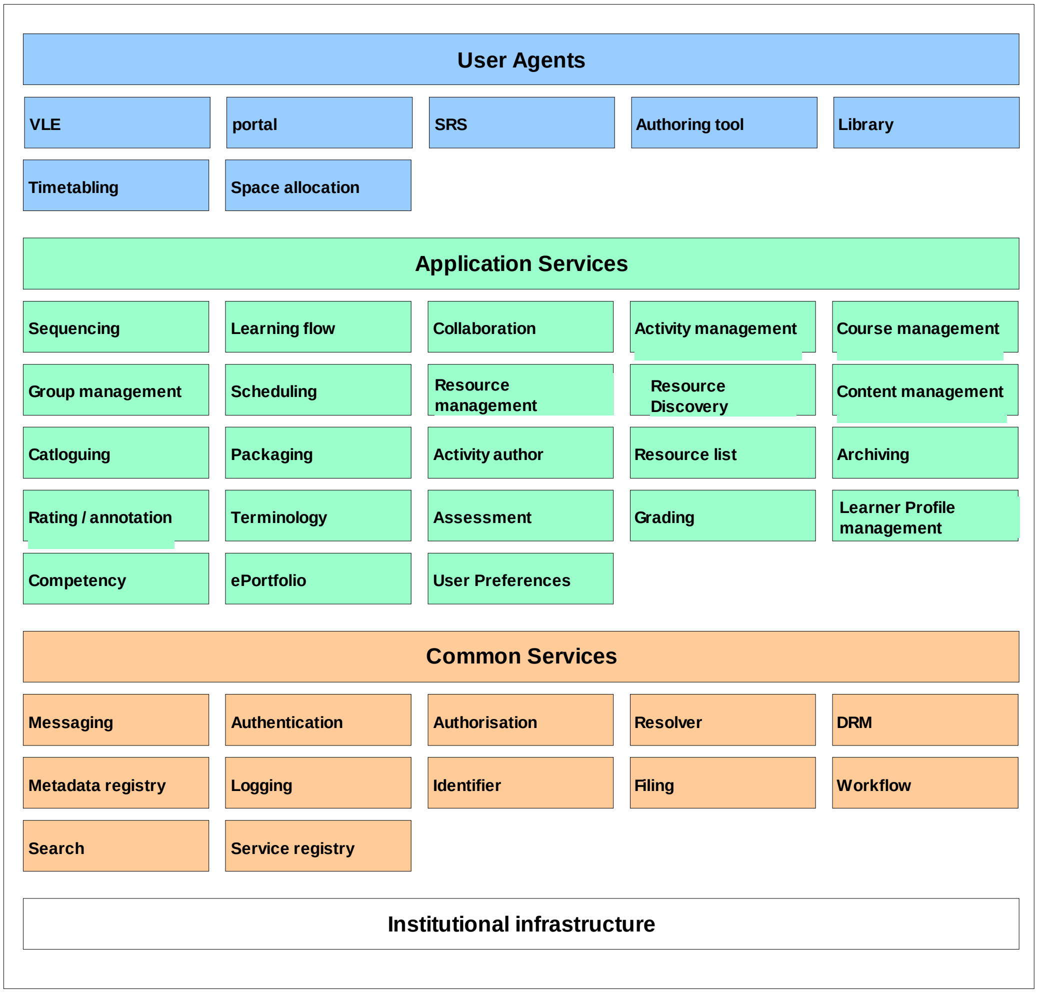

Figure 5 E-learning framework, based on the IMS abstract framework, and extended to meet the needs of the

1.7 Application Profiling

In almost all cases the specification or standard is not sufficient as they only define the basis from which application profiles can be developed to meet the particular needs of a community. The community might be a national or linguistic community that needs to be able to express vocabularies in a particular language, or it might be an educational sector such as schools or universities which share a set of common needs that may not be fully met by the specification. It must be remembered that the specifications have to cover the general case and meet the needs of all the communities that might want to use them.

A wide variety of application profiles have been defined and some of these will form the basis of the conformance testing within the Telcert project.

1.7.1 Developing an Application Profile

An application is the extension of a specification to meet the needs of a particular community whose needs cannot be met by the base specification. Therefore, the first task is the identification or establishment of a community of shared interests which can identify the need for an application profile and is able to support its development and maintenance.

Having established the scope and (at least the initial membership) of the community it needs to look at the requirements of its members. This should include both the needs of any existing systems and processes and likely future needs. Once requirements have been gathered, there needs to be a process of analysis and synthesis, where the community produces models of its domain, and identifies gaps in available specifications. This will include mapping the requirements against existing candidate specifications and applications profiles, and may also involve developing a reference architecture model to place the specifications within a system design context.

After the mapping of the requirements against existing specifications and application profiles has been undertaken it is necessary to decide whether any of the existing specifications or application profiles meet the community's needs, and if not which specification **or** other application profile forms the best basis for building an application profile for the community. It should be remembered that creating an application, and especially getting agreement from all parties, is a significant task, so that if there is already a suitable application profile then this should be used rather than creating a new one.

Finally, an initial application profile is created. Profiles need to be published, ideally in a registry of application profiles, so that developers have a place to find an authoritative version of the application profile and so that other organisations wishing to create profiles can locate and reuse existing work.

This is not the end of the overall process, as the profile still needs to be maintained, and the community must support its implementation.

This whole process is encapsulated in the diagram in Figure 6: Profile development process.

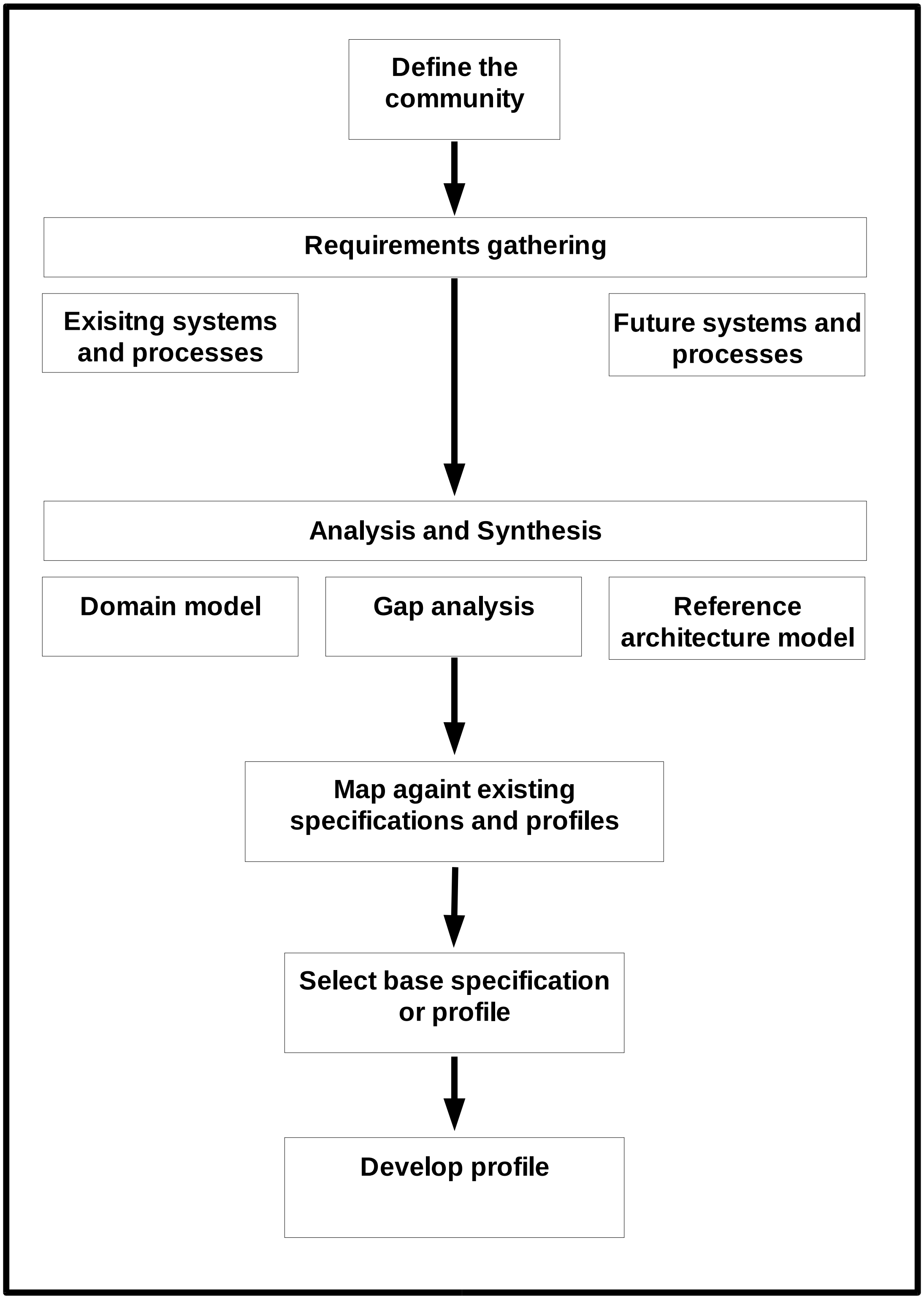

Figure 6: Profile development process

1.7.2 Types of Application Profile

Six types of application profile have been identified:

- A **Data Profile** consists only of a profile of an information model of a static structure. The original model may be expressed in formal notation, such as UML, or as a human-readable document. Sometime such a model is called a “Conceptual Data Schema”.
- A **Bound Data Profile** consists of a profile of both an information model and a binding for a static structure. The binding may be to XML, RDF, or some other technology. It is also possible that a Bound Data Profile will contain a single information model profile but more than one binding profile.
- A **Service Profile** consists of a profile of an abstract service definition. The service may be defined using UML models, as an OKI Open Service Interface Definition (OSID).
- A **Service and Data Profile** consists of both a profile of a service definition, and profiles of related information models of static structures. For example, an abstract interface model and its parameter data types - both expressed using UML - could be profiled using a Service and Data Profile.
- A **Service and Bound Data Profile** consists of both a profile of a service definition, and profiles of related static structures in both their information models and their bound forms.
- A **Bound Service Profile** is the complete set of profiles for the abstract service definition, the service binding (for example, in WSDL), the information models of its static structures, and their bindings.

1.7.3 Extending and refining base specifications

Two types of change can be made to a base specification. They can be constrained, for instance by limiting an existing vocabulary or they can be extended for instance by the inclusion of new items or the broadening of vocabularies. These have implications for interoperability with existing systems.

Where the application profile is only constraining an existing profile (or base specification) then anything compliant with the new application profile will also be compliant with the base specification; however, not all data produced by systems compliant with the base specifications will be compliant with the new application profile.

Where an application profile is extended by the addition of new features compatibility with the base specification is likely to be lost.

IMS [IMS04] have identified 25 different ways in which a specification can be modified in the creation of an application profile. These range from clarifying the meaning of a term, restricting its use through the definition of a vocabulary or the type of number that may be stored through to extending the model by adding new elements to the specification.

There are many reasons for wanting to create an application profile from a specification. These include translation into other languages – typically the specification is created in a single language, but where it will be used in more than one country a profile is needed.

Another important reason that application profiles are created is because the specification is generic, and it needs specific vocabularies to be added to meet local needs. There are numerous examples of this, and a couple of examples include:

- RDN / LTSN LOM Application Profile (RLLOMAP). This is a further development of the UK LOM Core, which is itself an application profile of the IEEE LOM; however as both are created by restricting terms and adding vocabularies anything which is compliant with either the UK LOM Core or the RLLOMAP should also be compliant with IEEE LOM. However, it will be possible to create records that are compliant with IEEE LOM, but which do not make use of the relevant vocabularies and so are not compliant with the RLLOMAP.

- European Diploma Supplement (EDS). A Series of national application profiles are being developed to support the implementation of the EDS. EIfeL have produced an application profile for French Universities, while CETIS [CETIS04] and the Centre for Recording Achievement are working on a version for the UK higher and further educational markets

1.8 References

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