LUISA

Learning Content Management System Using Innovative Semantic Web Services Architecture

IST- FP6 - 027149

Deliverable D4.2

LOMR integration specification

Miguel-Angel Sicilia
Salvador Sanchez
Sinuhé Arroyo
Sergio Martín-Cantero

Due date of deliverable: 28/02/2007

Actual submission date: 28/02/2007

Start date of the project: 01/03/2006 Duration: 30 Months

Miguel-Angel Sicilia
University of Alcalá

Version 1.0, dated 20/01/2007

Change History

Version	Date	Status	Author (Partner)	Description
0.1	10.01.2007	Initial Draft	Miguel-Angel Sicilia	First draft
1.0	30.03.2007	Reviewed version	Miguel-Angel Sicilia	The changes from the review process have been introduced.

EXECUTIVE SUMMARY

This deliverable describes the approach for the integration of the LUISA LOMR component with existing repositories. The main alternatives are delineated, and the rationale for the selected approach is provided.

The departure point for the integration approach in LUISA is that there is an asymmetry when bridging from conventional, non-semantic learning object repositories to semantic ones as the LUISA LOMR instances. This leads to considering import of non-semantic data as the more valuable approach, since it allows for exploiting existing metadata which later can be enriched with semantics.

Document Information

IST Project Number	FP6 – 027149	**Acronym**	LUISA
Full title	Learning Content Management System Using Innovative Semantic Web Services Architecture		
Project URL	http://www.luisa-project.eu /		
Document URL			
EU Project officer	Kypros Kyprianou		

Deliverable	**Number**	4.2	**Title**	LOMR integration specification
Work package	**Number**	4	**Title**	Learning Object Metadata Repositories and LOMR Integration Development

Date of delivery	**Contractual**	28.02.07	**Actual**	28.02.07
Status	Version 1.0, dated 20/01/2007		final ☑	
Nature	Report ☑ Demonstrator ☐ Other ☐			
Dissemination Level	Public ☑ Consortium ☐			
Abstract (for dissemination)	This deliverable describes the approach for the integration of LUISA LOMR with existing learning object repositories and educational metadata.			
Keywords	Learning objects, learning object repositories, Semantic Web, Semantic Web Services, ontologies, WSMO, IRS-III			

Authors (Partner)	Miguel-Angel Sicilia (UAH), Salvador Sánchez-Alonso (UAH), Sinuhé Arroyo (UAH), Sergio Martín-Cantero (UAH)			
Responsible Author	Miguel Angel Sicilia		**Email**	msicilia@uah.es
	Partner	UAH	**Phone**	+34 91 886 6603

Project Consortium Information

Partner	Acronym	Contact
Atos Origin S.A.E. (Coordinator)	ATOS	Nuria de Lama Atos Origin S.A.E. c/ Albasanz 12 E-28037 Madrid, Spain Email: nuria.delama@atosorigin.com Tel.: +34 91 214 9321 Fax:+34 91 754 3252
University of Alcalá de Henares	UAH	Dr. Miguel-Angel Sicilia Information Research Unit University of Alcalá Ctra. De Barcelona, Km 33.6 E-28871Alcalá de Henares (Madrid), Spain Email: msicilia@uah.es Tel.: +34 91 886 6603 Fax: +34 91 885 6646
University of Uppsala	ULL	Dr. Ambjorn Naeve University of Uppsala Kyrkogårdsgatan 2 C Uppsala Email: amb@nada.kth.se Fax: +46 184-716-294
Open University	OU	Dr. John Domingue Knowledge Media Institute, The Open University, Walton Hall, Milton Keynes, MK7 6AA, United Kingdom Email: j.b.domingue@open.ac.uk Tel.: +44 1908 655014 Fax: +44 1908-653-169
University Henri Poincaré	UHP	Dr. Monique Grandbastien University Henri Poincaré Vandoeuvre les Nancy 54506, PO Box 239, France. Email: monique.grandbastien@loria.fr Fax: +33 383-278-319
Giunti Interactive Labs S.r.l.	GIUNTI	Dr. Fabrizio Giorgini Giunti Interactive Labs S.r.l. Abbazia dell'Annunziata Via Portobello Baia del Silenzio 16039 Sestri Levante (GE), Italy Tel.: +39.0185.42123 Fax: +39.0185.43347
EADS – Corporate Research Centre		Anne Monceaux EADS – Corporate Research Centre Avenue Didier Daurat - Centreda 1,Toulouse, 31700, France. Email: anne.monceaux@airbus.com Tel.: +33 561-184-725 Fax: +33 561-187-611

TABLE OF CONTENTS

1 INTRODUCTION

The mission of LUISA is that of exploiting the advantages of a Semantic Web Service Architecture to make richer and more flexible the processes of query and specification of learning needs in the context of Learning Management Systems and Learning Object Repositories.

This document describes the outcomes of task 4.2. “LOMR integration specification”, along with some advances in actual implementations of import interfaces from existing repositories. The overall architectural specification will be extended to integrate concrete cases of common integration interfaces with existing repositories.

The integration approach in LUISA takes a different position from the approaches usually followed in non-semantic implementations. While for non-semantic data sources, two-way communication makes sense as an information exchange, the bridging of semantic and non-semantic sources leads to emphasizing importing non-semantic data. In other words, non-semantic data can be used as a point of departure on semantic repositories (although it does not by itself bring the value of the semantic approach), but the enhanced semantics can not be exported to non-semantic sources, due to the representational mismatch between data modelling schemas and logics-based ontological representations.

From those departure assumptions, several integration options can be identified. The proposed approach for LUISA is that of providing the required import facilities, including when needed specific adapters. This can be complemented with compliancy with some existing reference frameworks specific to learning object repositories. In that way, LUISA LOMR instances are able to exploit existing metadata, and they also behave as conventional repositories, but providing advanced query languages or query resolution strategies. This is the overall approach described here, which design has been incorporated in the ongoing implementation of the LUISA LOMR Architectural prototype.

The document is structured as follows. Section 2 provides background information on LUISA architecture and on the specifics of the LUISA LOMR as a component of the LUISA Architecture. Then, Section 3 details the integration options considered. Section 4 deals with the selected approach. Finally, Section 5 discusses possible future directions.

2 BACKGROUND: OVERALL ARCHITECTURE OF LUISA AND LUISA LOMR

This section provides a brief synthesis of the state of the overall LUISA architecture as the big picture of the whole project in which the LOMR architecture discussed plays a role.

2.1 Overall LUISA Architecture

The main components of the LUISA framework architecture are depicted in Figure 1.

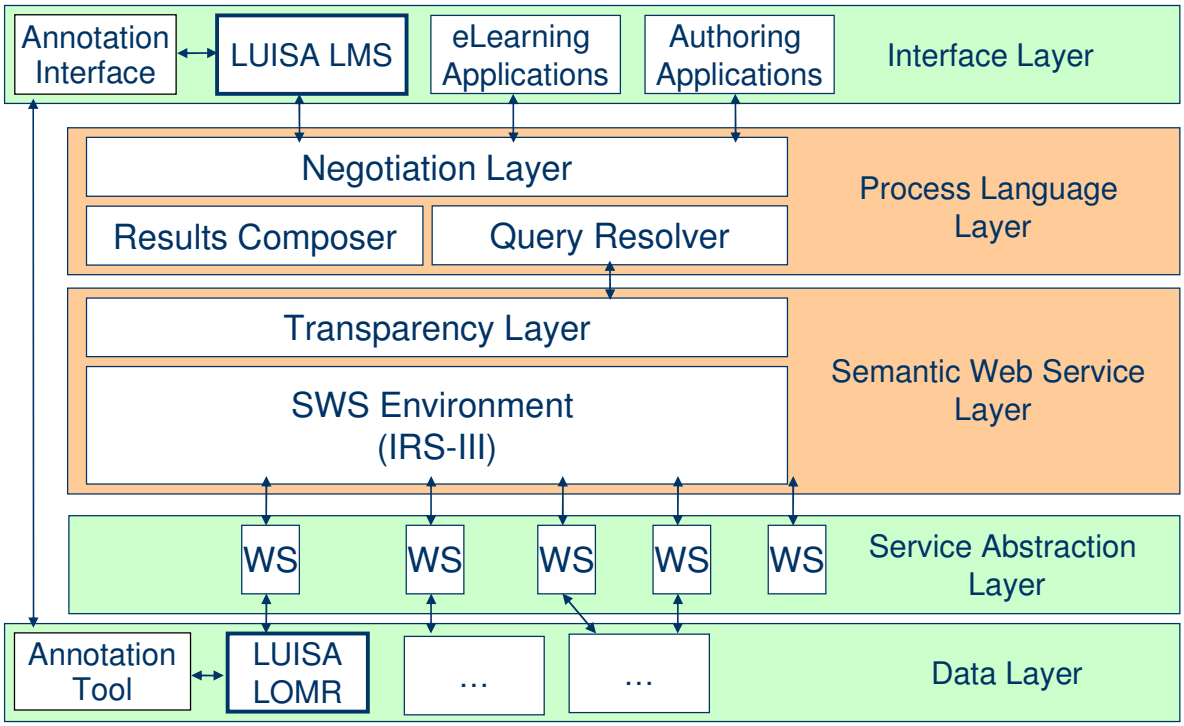

Figure 1. Main components of the LUISA Architecture.

The architectural prototype specification described here deals with the specific of LUISA LOMR repositories, labelled as *Data Layer* in the picture. The *Data Layer* thus serves as the provider for the rest of the architecture. Since there exists a considerable number of learning repositories, it is important for LUISA to exploit them, along with using the LUISA LOMR instances that provided Semantic Web-enabled metadata as an added value.

It should be noted that the *Semantic Web Service Layer* is capable of selecting any kind of repositories (not only LUISA LOMR instances) provided that the semantic descriptions for the data provided by those repositories is properly specified. However, in LUISA LOMR instances the semantic descriptions of the Web services are coherently aligned with the ontologies used as schema for the storage of learning object metadata.

2.2 LUISA LOMR Architecture

Deliverable 4.1. "*LOMR overall architecture*" provided the following Architectural instantiation as the target for the LOMR reference implementation.

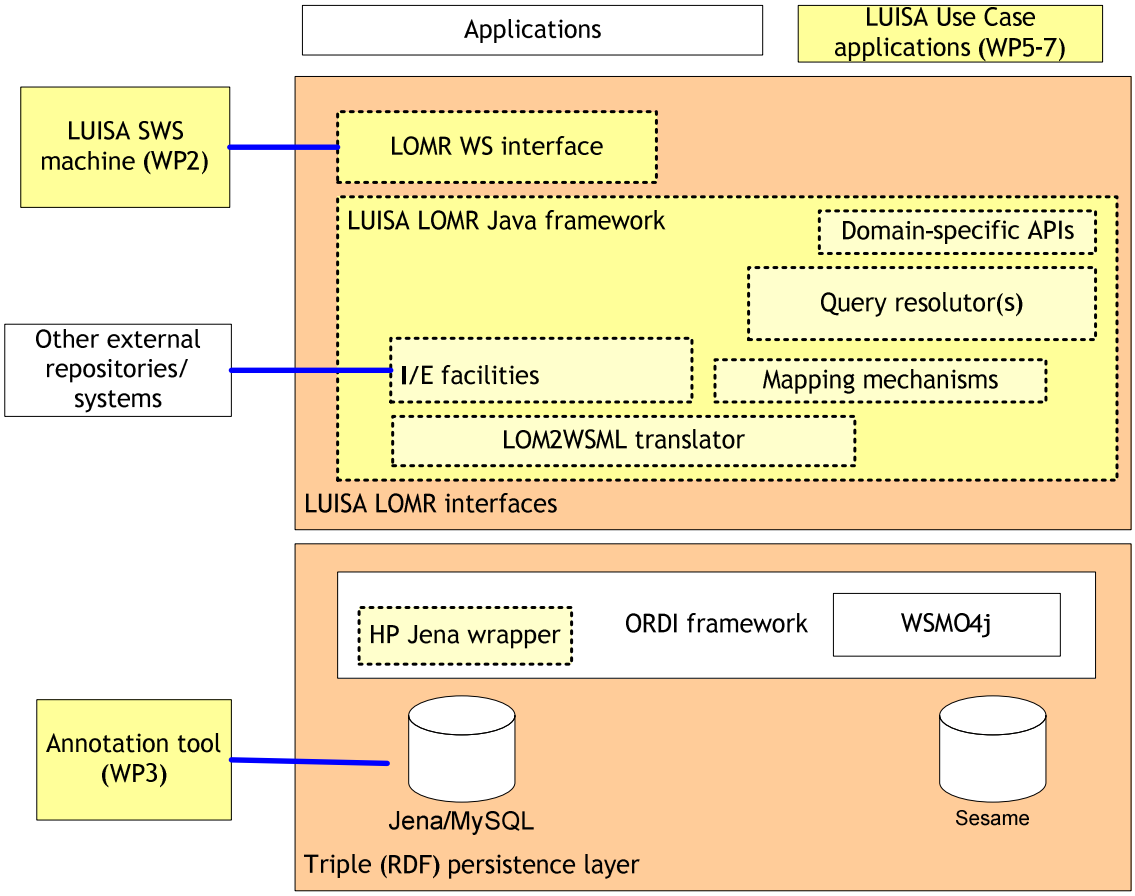

Figure 2. LOMR Architectural prototype architecture (as in deliverable 4.3 version 1.0)

The architectural prototype details that architecture into a more detailed layered view which considers specific libraries, frameworks and technologies. Here the Import/Export facilities from/to other repositories are yet identified as a component for which a part of the implementation will be delivered in the prototype. Some other components will be devised for integration as detailed below.

3 INTEGRATION OPTIONS IDENTIFIED

This section briefly outlines the integration options identified. In all the cases, the options considered are constrained by the following asymmetric mediation principle that refers to the *semantic gap* between non-semantic learning object metadata repositories (NS-LOMR) and semantic learning object metadata repositories (S-LOMR) – of which the LUISA LOMR is a concrete implementation.

The asymmetric mediation principle

A *Mediator* bridging a NS-LOMR and a S-LOMR bridges two representation languages for describing the same entities. The mediation from the former to the latter can be done without loss of information, but the reverse is not true in the general case.

For example, if we have two repositories covering the information in the IEEE LOM schema, with the former (let's call it A) using the IEEE LOM XML mapping and the latter (let's call it B) using ontologies for describing the learning objects, the mediator losses the semantics of the ontology when doing the translation from B to A. Such semantics probably include some of the following:

- Links from standard IEEE LOM metadata to elements in domain ontologies.
- Formal versions of some metadata elements, like for example, *relations* between learning objects.
- Axioms and definitional constraints on concepts, used for the automated classification of instances.
- Information split up for semantic accuracy, e.g. the splitting of *coverage* information in different facets expressed through ontology instances, instead of providing a single string-type element that mixes different aspects.

This asymmetry was highlighted in the overall LOMR architecture when considering the IMS DRI specification. An S-LOMR could implement the functions in IMS DRI, but additional functions are required to exploit the capabilities of S-LOMR, as semantic search or asserting metadata in a semantic form (Rodríguez, Sicilia and Arroyo, 2006).

In addition to considering asymmetry, it is important to highlight that the Service-oriented approach of LUISA requires loosely coupled integration options. In consequence, the integration facilities could be considered at the following levels:

1. Interchange facilities through common formats, as those considered for import facilities.
2. High-level, service-oriented protocols for queries and data interchange as LOIF (see below).

3. Distributed referencing, which allows for a separation of concern between repositories, and reuses existing systems without requiring any change in them.

An additional important aspect of the LUISA LOMR integration approach is that Service-oriented learning object interoperability frameworks and learning object specifications and standards are in an state of continuous evolution and has still not reached a high status of maturity.

3.1. Import/Export Facilities

Since LUISA is aimed at being standards-compliant, the focus of the import/export facilities is oriented to existing standards (or specifications not having the status of *de iure* standard but that are open and widely used).

Currently only the IEEE LOM metadata schema is an official international standard, which leads to the requirement of being able to take advantage on the current investment in storing IEEE LOM records.

Other specifications as IMS LD or IMS QTI are quickly becoming widely adopted. However, the inclusion of facilities for import/export of data conforming to them will be done only if required for the specific of LUISA case studies or demonstrators.

3.2. Supporting Protocols specific to Learning Object Repositories

Interchange formats as the XML mapping of IEEE LOM are an option for data exchange. However, some other specifications also address the functional aspects of the integration. There are a number of specifications or open protocols for the description of digital resources. However, only a few are specific to the domain of educational resources. Among them, the most relevant are:

1) The IMS DRI specification[1], currently in its 1.0 version. This specification aim is "*to provide recommendations for the interoperation of the most common repository functions*". Even though the specification is not restricted to educational resources, it considers IMS specifications that are usually used for that purpose. IMS DRI in its current version provides a functional architecture and some recommendations for implementation based on Web Services.

2) The *Learning Object Repository Interoperability Framework*[2] (LOIF). This initiative is an open, collaborative effort, under the auspices of the CEN/ISSS Learning Technologies Workshop, to achieve interoperability between learning object repositories. It offers a Web Service oriented approach and provides a high level framework, not tied to specific query languages or data interchange formats.

[1] http://www.imsglobal.org/digitalrepositories/index.html

[2] http://www.imsglobal.org/digitalrepositories/index.html

Both specifications have been considered as possible targets for LUISA LOMR integration in term of repository functionality. The design decision is described below.

3.2. Building Facades

A complementary approach to integration could be that of building *Facades* (that is, simpler interfaces to the LUISA LOMR) that expose a subset of LUISA capabilities as a conventional repository. For example, LUISA LOMR implementations could provide a facade to offer a IMS DRI interface for interchanging content packages.

3.3. LUISA LOMRs as Proxies

LUISA LOMRs could be set up as *Proxies* for existing learning object repositories. In this case, the LUISA LOMR is an independent, alternative access point to an existing resource base, which is of special interest for comparing semantic and non-semantic accesses. The LUISA LOMR could act a as a proxy for the resources – and not for the (non-semantic) metadata. This fits in the notion of disparate metadata records for the same resources (Downes, 2004). For example, Figure 3 shows a possible configuration of an existing repository.

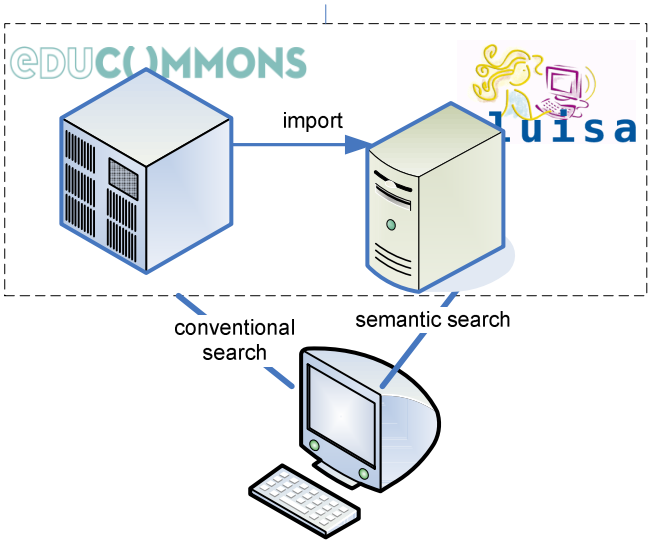

Figure 3. Example configuration for LUISA LOMR as a *Proxy*.

The benefits of the Proxy configuration is that common functions as editorial workflow or license management, which are not the target of semantic extensions, could still be used in the original repository software, keeping the semantic part separate.

Since LUISA LOMR instances store metadata, the only important requirement on conventional repositories to be integrated with LUISA technology is that they

provide some kind of permanent URL, which is a built-in characteristic of most modern repositories.

4 OVERALL APPROACH FOR THE INTEGRATION

The aspects considered for the integration provide different options for LOMR integration when combined in different arrangements. However, the approach in LUISA should be aligned with the objectives of the project as a demonstration of the Semantic Web approach considered an *extension* of the current state of the art. In consequence, the approach for the integration of the LOMR is based on two principles:

I. The LUISA LOMR must be capable of exploiting data in existing standard-based non semantic LOMR, for the purpose of enriching it with semantic annotations, which are the basis for the innovations in LUISA.

II. The LUISA LOMR must be capable of behaving as a specific kind of repository in the context of open and standard-based repositories.

Principle (I) is basically concerned with the importing of data from existing sources. However, the important point of such importing is that such data serves as a basis for its *enrichment*, so that semantic search would be based on the result of the enhancement of the existing records. This enables the exploration of semantic capabilities with a point of comparison in exiting search facilities.

Principle (II) entails the conformance of the design of the LUISA LOMR with existing interoperability specifications, so that they can establish a dialogue with other repositories by means of adapters.

The rest of this section details the approach decided for integrating with existing NS-LOMR in the reference implementation of the LUISA LOMR. Concretely, principle (I) leads to the requirement of providing import facilities, while principle (II) leads to provide the required design to adapt to evolving specifications of learning object repository interchange.

4.1. Import facilities

This section provides some additional detail on the import facilities that are to be included in the LUISA LOMR reference implementation.

4.1.1 The LOM2WSML translator

The main design principles behind the LOM2WSML translator were first described in [1].

Current metadata schemas as IEEE LOM or DCMI provide XML mappings in terms of a number of metadata elements or “fields”. In IEEE LOM, these are organized in categories, and a number of data types as *LangStrings* and *Duration*s are defined in the specification. However, these elements in LUISA ontology do not always have a direct mapping to a type in the language. Then, a type-to-type and element-to-element mapping is required as those described in [1]. Then, separate translators for identified kinds of translators are identified. The structure of these libraries is exemplified in Figure 4.

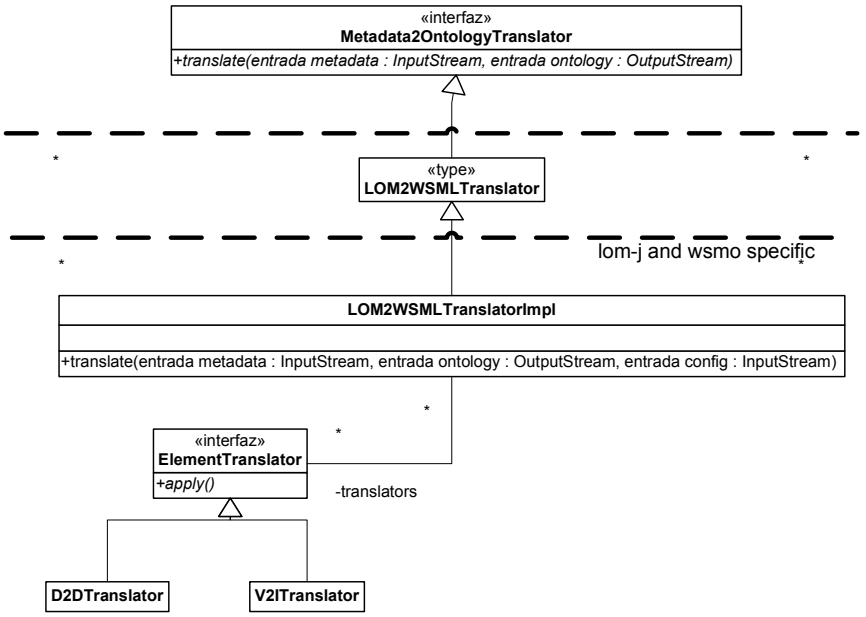

Fig 4. Main elements of the mapping design

The LOM2WSML libraries are a import facility for IEEE LOM metadata records expressed in XML of which a version is actually developed and integrated in the LUISA LOMR architectural prototype. The basic structure of these libraries is depicted in Figure 5.

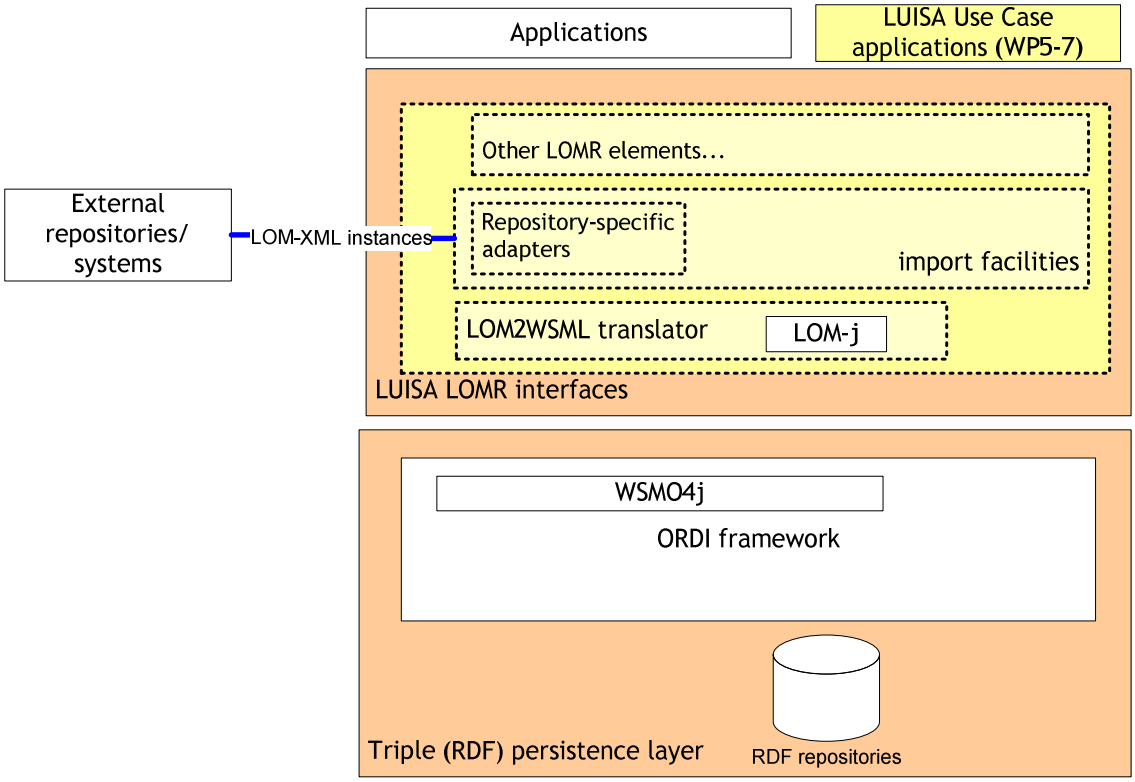

Fig 5. LOM2WSML layered positioning in the LUISA LOMR architecture

Figure 5 provides a simplified view of the LUISA LOMR architectural prototype, emphasizing the location of the LOM2WSML-based import facilities.

4.1.2 Adapter for CAREO

The CAREO repository[3] is an open framework for instantiating learning object metadata repositories. The LOM2WSML libraries have required a `CAREOAdapter` class that bridges some mismatches in the syntax of some fields of the LOM metadata records that are imported from CAREO.

4.1.3 Adapter for ARIADNE bulk data

The ARIADNE foundation provides a bulk download of IEEE LOM metadata records[4]. The LOM2WSML libraries have required a `ARIADNEAdapter` class that bridges some mismatches in the syntax of some fields of the LOM metadata records

4.2. Support for the LORI framework

The recent *Learning Object Interoperability Framework* (LOIF) is an evolving specification that aims at solving the specific issues of learning object repository interoperability by addressing different levels depicted in Figure 6.

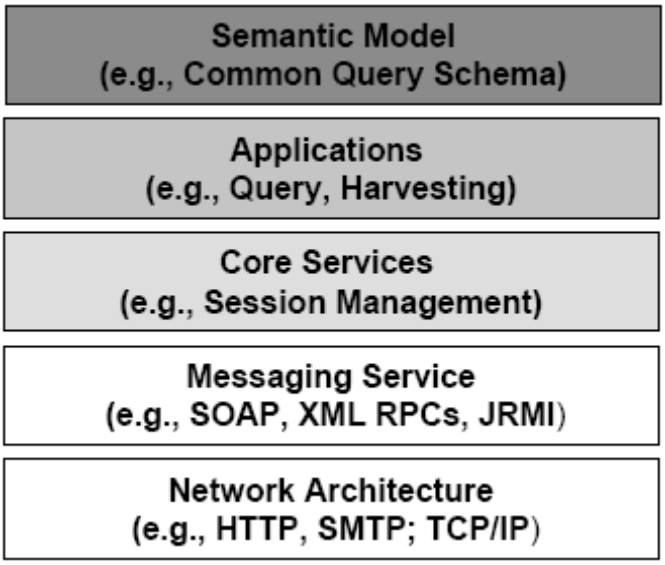

Fig 6. Learning Object Repository Interoperability Stack

The overall LUISA architecture is compatible with the two bottom layers. The current version of the framework (1.0) deals with session management and a simple protocol for query services. The specification is the most generic in the specific domain of learning objects.

IMS DRI provides to date only a generic functional view of the repositories and then specific guidelines for IMS compatible content and some other legacy

[3] http://careo.ucalgary.ca

[4] http://ariadne.cs.kuleuven.ac.be/ariadne/

query languages as Z39.50. Since LUISA LOMR only stores metadata, compatibility with IMS DRI is not considered a critical issue, and it is discarded for the integration specification.

In consequence, the LOIF provides a more format-agnostic framework. This is the reason why it has been selected as the target for the LUISA LOMR. It provides two features that are of a special interest to LUISA:

1. Session management is a required capability for providing personalization to search, which is a natural extension to the LUISA architecture.
2. The possibility of accommodating multiple query languages is consistent with the LUISA approach to having different, specialized *query resolvers*. Thus, messages in different query languages can be routed to the appropriate query resolver, providing built-in support for experimenting with different techniques.

Concretely, the design of the LUISA LOMR framework will be adapted to support the session management in the synchronous case and the adapters for the SQI query service. The details are embedded in the detailed design of the Architectural prototype.

4.3. Support for Proxy configurations

The setting of a LUISA LOMR as a *Proxy* for an existing repository requires support for the mapping of learning object identifiers from the NS-LOMR to the LUISA LOMR.

Since there is not a universal, standard naming scheme for learning object metadata records, existing repositories usually use (internal) numeric or alphanumeric identifiers. In the LUISA LOMR, the concept of *Learning Object Reference* is the mechanism to identify semantic metadata records inside LUISA LOMR(s). Thus, a mapping scheme from such references to external, repository-specific references has been included in the LUISA LOMR framework.

Once the naming scheme is resolved, setting LUISA as a proxy only requires a first import phase of conventional metadata, and some mechanism for updating the metadata in LUISA whenever some learning object is deleted/added to the conventional repository.

The configuration of LUISA as a proxy has the added benefit of allowing several conventional repositories to be intermediated through the same LUISA LOMR proxie. This is especially useful when several repositories on the same domain(s) use different schemas or technologies. In that case, the LUISA LOMR serves the additional function of an indirect federator for heterogeneous technology.

5 OUTLOOK

This document has described the LUISA LOMR integration options selected for inclusion in the reference implementation. The main idea is that the LOMR should be able to import existing metadata in standard formats, and that the design of the LOMR should provide the required structure for accommodating state-of-the art interoperability specifications.

Learning object interoperability is an evolving technological area for which it is reasonable to expect new standards and specifications in the future. As such, the design of the LUISA LOMR attempts to be generic enough to accommodate such changes.

REFERENCES

[1] Downes, S. (2004). Resource Profiles. *Journal of Interactive Media in Education*, 2004 (5).

[2] Rodriguez, E., Sicilia, M.A. and Arroyo, S. (2006) Bridging the semantic gap in standards-based learning object repositories. In *Proceedings of the Workshop on Learning Object Repositories as Digital Libraries: Current challenges*, part of the 10th European Conference on Digital Libraries, Alicante, Spain.