

# **LUISA**

*Learning Content Management System Using Innovative Semantic Web Services Architecture*

**IST- FP6 - 027149**



## **Deliverable D2.1**

**Semantic Web Service Infrastructure for e-Learning Applications: using WSMO for linking LO Standards and representing Processes**

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## **EXECUTIVE SUMMARY**

In this deliverable we describe the first results in the implementation of the SWS infrastructure of the LUISA project. The SWS Infrastructure aims at brokering between generic e-Learning applications and Learning Object Metadata Repositories by introducing a context-adaptive SWS-oriented approach. In this document, we describe our vision and approach, before introducing the designed general architecture and detailing the functional and semantic components implemented so far. Furthermore, this deliverable represents a reference document for the developments of designed components or the introduction of new ones.

## Document Information








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## TABLE OF CONTENTS

<b>EXECUTIVE SUMMARY .....</b>	<b>3</b>
<b>TABLE OF CONTENTS.....</b>	<b>6</b>
<b>1 INTRODUCTION.....</b>	<b>7</b>
<b>2 BACKGROUND: ISSUES WITHIN E-LEARNING .....</b>	<b>8</b>
<b>3 VISION: DYNAMIC ALLOCATION OF LEARNING RESOURCES BASED ON SWS .....</b>	<b>10</b>
<b>4 LINKING WSMO AND E-LEARNING STANDARDS – A CONCEPTUAL FRAMEWORK .</b>	<b>11</b>
4.1 Abstraction from Learning Data and Functionalities .....	11
4.2 Abstraction from Learning Process Metadata .....	12
<b>5 SWS-BASED INFRASTRUCTURE FOR E-LEARNING .....</b>	<b>12</b>
5.1 LUISA Infrastructure Architecture .....	12
5.2 Interface Layer .....	13
5.3 Process Language Layer .....	13
5.4 Semantic Web Service Layer.....	14
5.5 Service Layer .....	15
5.6 Data Layer .....	15
<b>6 PROCESS LANGUAGE LAYER: ONTOLOGIES .....</b>	<b>16</b>
6.1 Ontology Stack .....	16
6.2 Semantic Learning Process Model Layer .....	17
6.3 Mapping with eLearning Metadata Standards.....	18
<b>7 PROCESS LANGUAGE LAYER: ARCHITECTURAL COMPONENTS.....</b>	<b>20</b>
7.1 Negotiation Layer.....	22
7.2 Query Manager .....	22
7.3 Composition Manager .....	23
<b>8 CONCLUSION AND OUTLOOK .....</b>	<b>23</b>
<b>REFERENCES .....</b>	<b>26</b>

## 1 INTRODUCTION

E-Learning is aimed at supporting individuals in fulfilling a specific learning need within a specific situation through the use of information and communications technology. To achieve this aim, the current state of the art is represented by approaches considering the usage of software systems – e. g. learning content management systems (LCMS) – which provide a learner with composite learning content – the so called learning objects. These composite objects are described by using existing metadata standards and contain the learning resources - the physical data assets – as well as a description of the learning process to be followed by the learner. This approach limits the re-usability of such composite learning objects as well as restricts the ability of a learning application to adapt dynamically to specific learning demands and contexts (cf. [2], [11]).

To overcome these issues, the approach utilized in LUISA changes this data- or content-based paradigm to an highly dynamic service-oriented approach based on semantic web service technologies. We follow the idea of replacing the current approach of providing the learner with learning data with a dynamic supply of appropriate learning related functionalities in order to enable a dynamic adaptation to the learning context at runtime of a learning process. To enable this vision, our approach is fundamentally based on abstracting from learning data as well as from existing learning process models by using semantic web as well as semantic web service technology. By describing a learning process semantically as a composition of learning goals and independent from any metadata standard, a learning process model can be mapped to different metadata standards to achieve compliancy with these standards.

This document describes the outcomes of the work on tasks 2.1. “SWS based Infrastructure for eLearning Applications”, 2.3 “Linking WSMO enhanced Ontologies to Learning Object Standards”, and 2.4 “WSMO Process Language”

The document is structured as follows. Section 2 provides background information about issues within current eLearning approaches we are going to address. Section 3 introduces our vision to enable context-adaptive and highly dynamic eLearning applications whereas section 4 describes a conceptual framework we are following to realise our vision and to map between WSMO (Web Service Modelling Ontology) and eLearning standards (Task 2.3). Section 5 describes a SWS based infrastructure for eLearning (Task 2.2) which integrates the main components of the LUISA project and supports our conceptual framework. In addition, we introduce ontology for learning processes in Section 6 as well as the architectural components needed to support learning processes in Section 7 (Task 2.4). Finally we draw a conclusion and provide an outlook to future work within LUISA.

## 2 BACKGROUND: ISSUES WITHIN E-LEARNING

Current approaches to support e-learning are entirely based on providing a learner with learning content appropriate to a given learning objective. To achieve the interoperability between different learning software platforms, several metadata standards are available aimed at providing a common specification for describing complex learning objects as well as the sequencing which has to be followed by the learner to fulfil his current learning need. Widely established e-learning standards in this area are IEEE LOM [5], ADL SCORM [1] – based on IMS Simple Sequencing [10] - or IMS Learning Design (IMS LD) [9]. Complex learning objects are distributed as composite content packages containing the learning resources as well as its metadata. Thus, learning support usually follows the following practices:

- Use of specific metadata and learning resources – whether data or services - to support a specific learning objective
- Resources are manually associated with specific learning objectives based on the subjective appraisals of a individual learning designer
- Learning resources are allocated at design-time, i. e. when the actual learning context is not known

Due to these facts, the following limitations have been identified (cf. [2], [4], [11]):

L1. *Limited appropriateness and dynamic adaptability to actual learning contexts.* It is assumed that every learning objective occurs in a specific context which is defined by e. g. the preferences of the actual learner – e. g. his native language or his technical platform. Learning data is allocated at design-time of a learning process – i. e. when the composite content package is developed. This limits the appropriateness of the data to the actual learning context, since the actual learning context can only be considered at runtime of a learning process. Moreover, the use of data excludes the dynamic adaptability a priori. In parallel to data-centric approaches, analogous issues can also be observed with service-oriented approaches. However, in that case, these issues are related to the allocation of services only.

L2. *Limited re-usability across different learning contexts and metadata standards.* Due to L1, for every different learning context or specific learner requirement a new learning content package has to be developed. For example, a learning package suiting the needs of a learner with specific preferences – e. g. his native language – cannot be used for other contexts or learners having distinct requirements. Since metadata is described based on standard-specific specifications, an individual content package cannot be reused across different standards.

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L3. *High development costs.* Due to L1 and L2, high development costs have to be taken into account when developing standard-compliant eLearning packages.

### **3 VISION: DYNAMIC ALLOCATION OF LEARNING RESOURCES BASED ON SWS**

To overcome the limitations described above, we consider the automatic allocation and invocation of functionalities at run-time. A typical learning related service functionality provides the learner for example with facilities to discuss about a specific learning topic or provides appropriate learning content. Since services are selected and invoked dynamically at runtime, a highly dynamic adaptation to different learning contexts and learner needs is supported. Learning processes are described semantically in terms of a composition of user objectives (goals) to abstract from specific data and metadata standards. This vision is radically distinctive to the current state of the art in this area, since it shifts from a data- and metadata-centric paradigm to a context-adaptive service-oriented approach. Moreover, using adequate mappings, our standard-independent process models can be translated into existing metadata standards in order to enable a reuse within existing standard-compliant runtime environments.

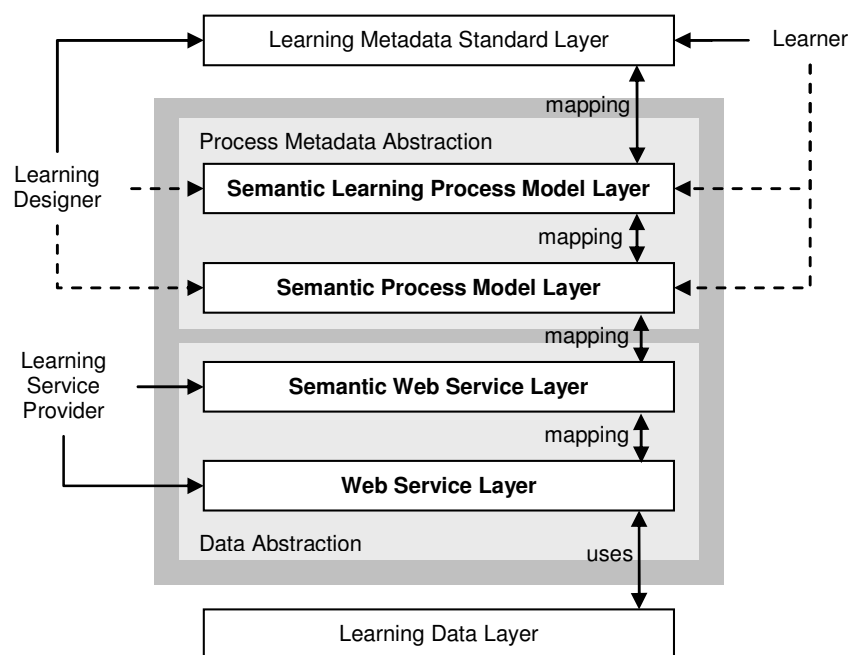
Addressing the limitations L1 and L2 identified in Section 3, we consequently reduce the efforts of creating learning process models (L3): one unique learning process model can adapt dynamically to different process contexts and can be translated into different process metadata standards.

## 4 LINKING WSMO AND E-LEARNING STANDARDS – A CONCEPTUAL FRAMEWORK

Our approach is fundamentally based on utilizing SWS technologies to realize the following principles:

1. **Abstraction from learning data and learning functionalities:** based on SWS technology
2. **Abstraction from learning process metadata standards:** based on semantic learning process models

To support these principles, we introduce several layers as well as a mapping between them in order to achieve a gradual abstraction. The following figure depicts this conceptual framework:



**Fig. 1.** Semantic layer architecture for supporting learning processes through a standard-compliant SWSOA

### 4.1 Abstraction from Learning Data and Functionalities

To abstract from existing learning data and content we consider a Web Service Layer. It operates on top of the data and is aimed at providing functionalities appropriate to fulfil specific learning objectives. This first step enables a dynamic supply of appropriate learning data to suit a specific context and objective. This will be supported furthermore by the use of semantic

descriptions of available learning data. In order to abstract from these functionalities (web services), our approach introduces an additional layer – the Semantic Web Service Layer. The latter enables the dynamic selection, composition and invocation of appropriate web services. This is achieved on the basis of formal semantic, declarative descriptions of the capabilities of available services – based on WSMO - which enable the dynamic matching of services to specific user goal.

## 4.2 Abstraction from Learning Process Metadata

A first layer concerned with the abstraction from current learning process metadata standards is the Semantic Learning Process Model Layer. It allows the description of processes within the domain of eLearning in terms of higher level domain concepts - e. g. learning goals, learners or learning contexts. This layer is mapped to semantic representations of current learning metadata standards in order to enable the interoperability between different standards. To achieve a further abstraction from domain specific process models – whether it is e. g. a learning process, a business process or a communication process – we consider an upper level process model layer – the Semantic Process Model Layer. For instance, this supports the mapping between learning objectives and business objectives to support all kind of organizational processes.

Based on mappings between the described layers, upper level layers can utilize information at lower level layers. This particularly includes the dynamic selection and invocation of a web service (Web Service Layer) from, for instance, a standard-compliant learning application (Learning Application Standard Layer). This can be supported by using a mapping between a specific learning objective within a specific learning situation and a WSMO goal. This enables the dynamic selection and invocation of services appropriate to achieve a specific learning objective. As a result, a dynamic adaptation to the individual demands of the learner within a specific learning context is achieved by using existing standard-compliant learning applications.

To support the realization of the described conceptual framework, we provide ontologies which facilitate the introduced semantic layers. These are explained in Section 6 of the document.

## 5 SWS-BASED INFRASTRUCTURE FOR E-LEARNING

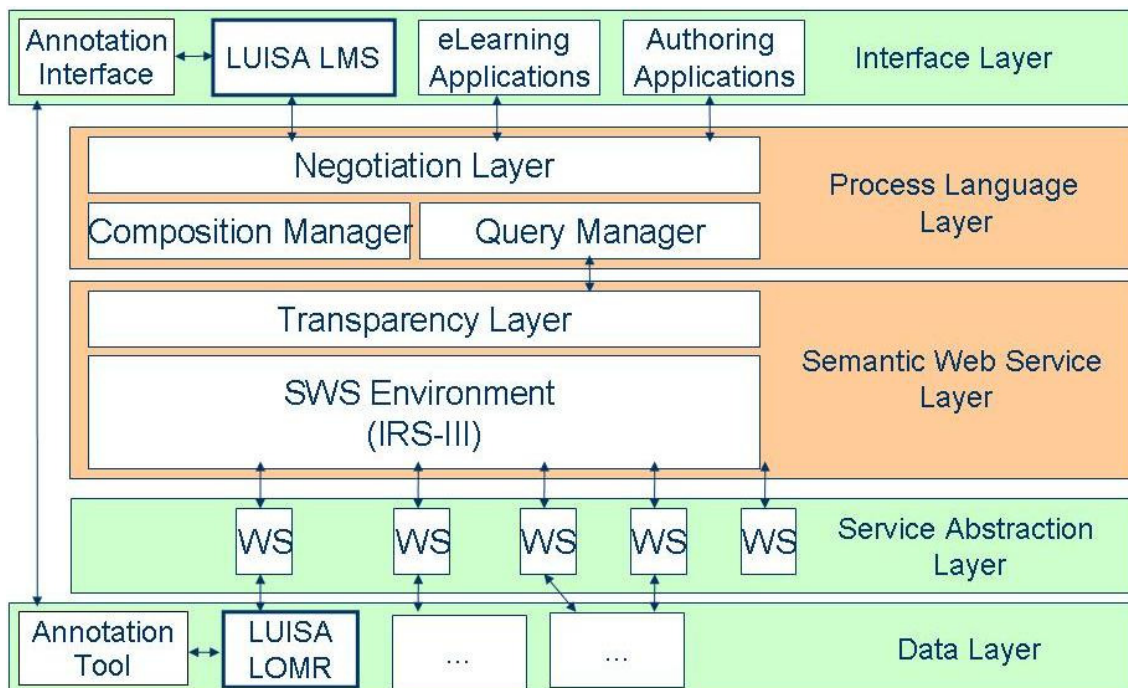
This section provides a synthesis of the state of the overall LUISA architecture. The main architectural components are outlined here, and their functionalities are briefly introduced.

### 5.1 LUISA Infrastructure Architecture

Figure 2 depicts the layered general architecture proposed by LUISA.

The two orange middle layers represent the actual SWS-based infrastructure for e-Learning that is developed within the WP2. These two layers are further detailed in the following sections of the present deliverable.

The green layers represent the actual interfaces of the SWS-based infrastructure. They are introduced only in this section to give to the reader a more comprehensive view, but they are not part of WP2 work. Since we aim to develop a general purpose infrastructure for e-Learning, the green layers do not contain LUISA-specific components only. LUISA-specific components of these layers are further detailed in distinct deliverables.



**Fig. 2.** Layered General Architecture proposed by LUISA.

## 5.2 Interface Layer

The Interface Layer contains all of the applications that may access the functionalities provided by the SWS Infrastructure as well as the tools that support the development of items stored within the SWS infrastructure. In particular, we distinguish two kinds of application: e-Learning and authoring. The first category represents applications that apply to end-user such as learners. The second category represents applications that apply to authors such as teacher as well as semantic developers. LUISA-specific components at this layer are: the Learning Management System (LMS) and the user interface of the Metadata Annotation Tool.

## 5.3 Process Language Layer

The Process Language Layer aims at supporting the learning objective of an end-user by using the functionalities provided by the Semantic Web Service Layer below. At this level such functionalities are described in terms of goal and

arranged by following specific descriptions (e.g. rules) to implement a learning design that fulfils the requested user objective. To accomplish this, we designed the following components:

- *Negotiation Layer*. The key functionality of this component is managing the interaction between the end-user application and the Semantic Web Service Infrastructure. This involves gathering and providing data to and from the end-user application, sequencing the learning design and dealing with the negotiation of the provided results. These tasks are partly accomplished with the support of the two following components.
- *Query Manager*. The key functionality of this component is processing the rules that resolve a specific query (learning objective). This involves decomposing goals into sub-goals, invoking goals that will be accomplishments by the Semantic Web Service Layer, verifying/negotiating the obtained results, eventually invoking a goal again. It is important to note that the behavior of this component changes according to different contexts and scenarios (i.e. domains). For this reason we expect multiple “instances” of this component that can be – manually (i.e. from the user) or automatically - selected.
- *Composition Manager*. Since a single query may involve several goal invocations, we introduced this component that gathers the result of each goal invocation and composes them in a unique package. The obtained package is given back to negotiation layer and then to the end-user application.

## 5.4 Semantic Web Service Layer

The Semantic Web Service Layer is mainly composed of two components: Transparency Layer and SWS Environment.

The first one simply hides the specific features of the underlying WSMO-based SWS broker - i.e. WSMX or IRS-III – by providing a well defined interface to access SWS technology facilities. It is based on the APIs developed within the DIP project [5].

The second component is IRS-III [3], which plays the role of SWS broker in the LUISA Infrastructure. In particular, given a goal invocation, IRS-III (i) discovers a candidate set of Web services, (ii) selects the most appropriate, (iii) eventually mediates any mismatches at the data, ontological or business process level and (iv) invokes the selected Web services whilst adhering to any data, control flow and Web service invocation requirements. To achieve this, IRS-III utilises a set of SWS descriptions, which are composed of WSMO goals, mediators, and Web services, supported by relevant ontologies [22]. Note that we distinguish two main sets of SWS descriptions: *basic SWS* that simply wrap the Web services to fulfil goals; and *complex SWS* that require an orchestration of basic or complex SWS to fulfil complex goals.

## 5.5 Service Layer

The Service Layer exposes the functionalities available at the Data Layer as well as supporting functionalities (e.g. mediation and semantic mapping services) as Web services. The use of Web service technology allows us to abstract from the underlying hardware and software platforms. All of the Web services available at this level are semantically described within the SWS Environment above.

## 5.6 Data Layer

The Data Layer contains all of the possible systems that provide resources to support a learning process. For example, several learning object repositories may be available at this layer. The resources provided by available systems are issued through specific services, which may perform even complex computations (e.g. involving semantic reasoning). These services are exposed in the Service Layer.

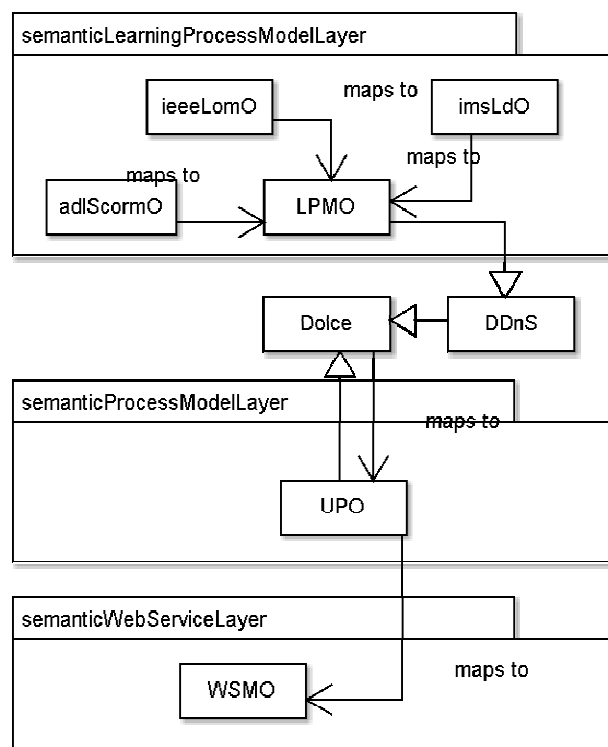
Our infrastructure is open to every kind of legacy system. However, a LUISA-specific component at this level is the LUISA Learning Object Metadata Repository (LOMR).

## 6 PROCESS LANGUAGE LAYER: ONTOLOGIES

This section describes an ontological framework aimed at implementing the introduced semantic layers. All ontologies are managed by the SWS environment (Figure 2) and will be mapped to the ontologies which will be provided by the use case partners (Work packages 6 and 7).

### 6.1 Ontology Stack

To implement the described semantic layers of our conceptual framework, we follow an approach of a staged ontological mapping between semantic models of a process at different levels of abstraction. Our approach considers different ontologies aimed at providing abstract semantic descriptions of data as well as processes. The figure below gives an overview of the main ontological representations considered in our approach as well as their relationships. Since this work is ongoing research at the moment, the proposed ontologies are partially implemented only at the moment.



**Fig. 3.** Conceptual overview of proposed ontology stack

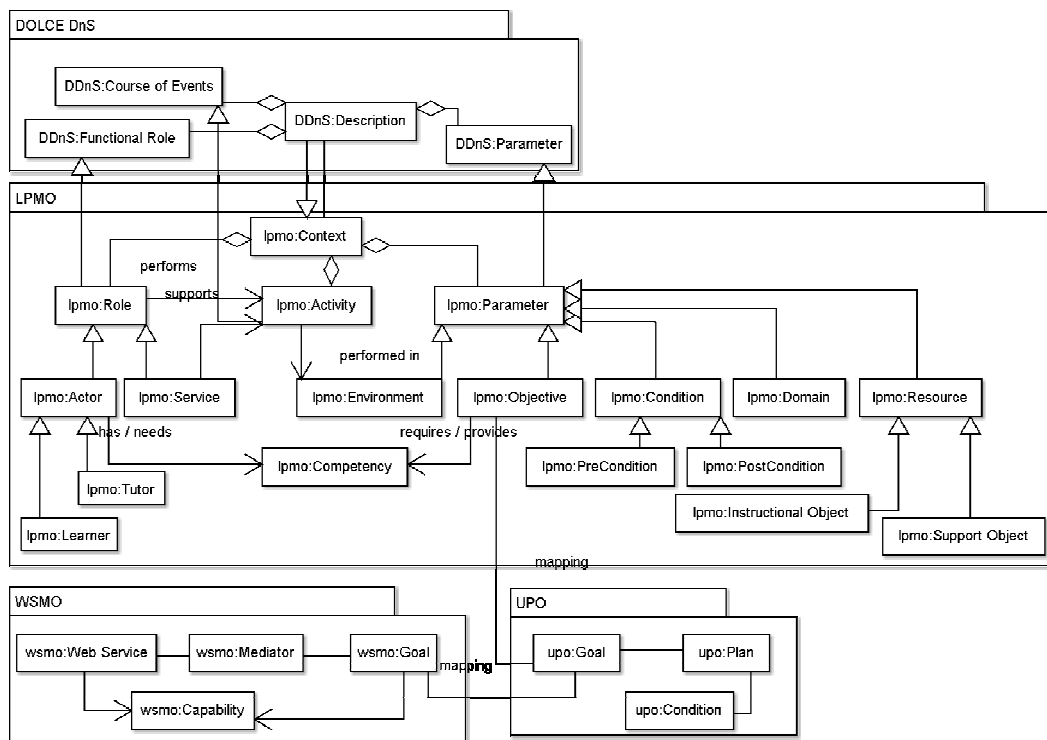
The Learning Process Modelling Ontology (LPMO) implements the Semantic Learning Process Model Layer and is aimed at modelling a learning process from a general point of view - independent from any supported platform or learning technology standard. It is mapped to ontological representations of e-learning metadata standards. Currently, representations of the following

metadata standards are introduced: ADL SCORM 2004 [1] (adlScormO), IMS Learning Design [9] (imsLdO) and IEEE LOM [5] (ieeeLomO).

The general Upper Process Ontology (UPO) abstracts from the process domain and implements the Semantic Process Model Layer. The UPO is currently being developed as part of the SUPER project [18] and will enable the description of a process independent from its specific purpose and can be mapped to domain specific process ontologies such as the LPMO. In order to enable a high level of interoperability of our ontologies, we intend to align the LPMO as well as the UPO to the DOLCE foundational ontology[8]. In particular, context descriptions are based on the Descriptions and Situations module (DDnS) [7] of Dolce. Furthermore, the UPO is mapped to the WSMO standard. Therefore, these ontologies realise a gradual mapping between as standard learning application and WSMO entities. It has to be highlighted, that our ontological architecture explicitly considers mappings not only between several semantic layers but also within a specific semantic layer. This enables for example the mapping of our LPMO concepts to other existing semantic descriptions of learning related concepts.

## 6.2 Semantic Learning Process Model Layer

From an e-learning perspective, the LPMO has to be perceived as the central ontology within our ontology stack, since it describes the semantics of a learning process from a general point of view and independent from any supported platform or learning technology standard. The following figure depicts an extract of the proposed LPMO containing some of its main concepts as well as some mappings to some key concepts within different semantic layers:



**Fig. 4.** Conceptual model of parts of the LPMO and key mappings to the UPO and the WSMO framework

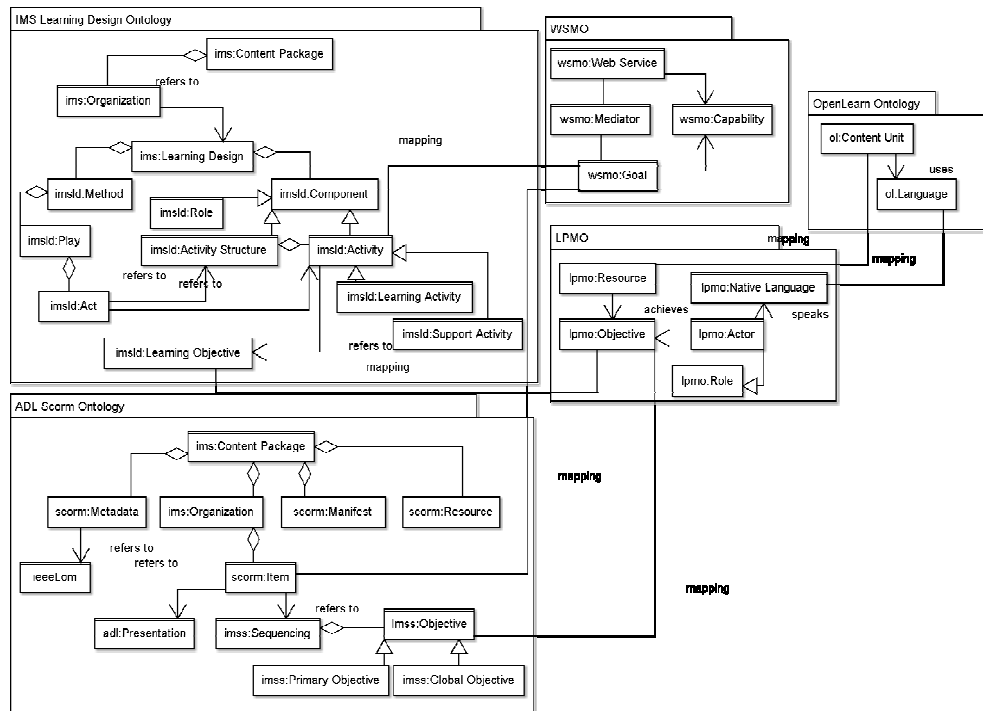
As shown above, a learning objective as defined in the LPMO is mapped to a `upo:Goal` – which represents a central concept within the Semantic Process Model Layer. This concept is furthermore mapped to the `wsmo:Goal` to enable a mapping and matching of appropriate web services. Besides the proposed mappings between several semantic layers, mappings are also considered within a specific layer to enable a wide applicability of our approach. E. g. semantic concepts of our LPMO can be mapped to other existing semantic concepts representing learning-related entities within different approaches – e. g. learning process modules as defined in [12], [13].

### 6.3 Mapping with eLearning Metadata Standards

In order to illustrate the mappings with existing eLearning metadata standards, this section explains some mappings which are implemented with a prototype application. Within this application, we introduced mappings between the LPMO, IMS LD, ADL SCORM, WSMO and utilized content entities. In particular, includes a mapping between the `Ipmo:Objective` and the objective description used within the IMS LD metadata (`imslld:Objective`) and the ADL SCORM metadata (`imss:Objective`). Furthermore, semantic learning object descriptions based on the LPMO are mapped to learning content provided by the Open Learn Project [14] based on an initial ontology representing these specific learning content objects. Besides that, a web service implements the mapping between the language of a content object (`ol:Language`) and the native language of the learner (`Ipmo:Language`).

It has to be highlighted, that our current prototype does not implement a mapping to the UPO. Instead, a WSMO goal is mapped to an IMS LD activity (imsld:Activity) as well as an ADL SCORM item (scorm:Item) directly.

The following figure depicts the main ontological mappings as implemented in our prototype:



**Fig. 5.** Key mappings with eLearning metadata standards

## 7 PROCESS LANGUAGE LAYER: ARCHITECTURAL COMPONENTS

This section describes the Process Language Layer as introduced in section 5.3. It has to be taken into account, that the current implementation of this layer is not utilizing the described ontological framework and is primarily aimed at interacting with the SWS broker to retrieve and compose learning objects. The assembly and composition of complex learning processes and the dynamic usage of the semantic descriptions within the SWS broker will be part of future work within LUISA.

The process of finding the appropriate learning objects starts with the raise of some kind of learning need submitted by the user of the LUISA system by the Interface Layer. This need can be expressed in simple terms as goals like “learner L from UHP requires learning about competency C”, but these goals could also be expressed as complex learning needs. Such complex descriptions may include requirements on the profile, previous competencies of the learner, discipline the learner wants to learn about, constraints of the technical platform in which the learning objects will be delivered, limitations on cost, duration or calendar of the resulting on-line learning design. These learning goals are then decomposable, in the sense that an overall goal can be broken up into simpler sub-goals that may be subject to independent inquiry.

The process of learning is then dependable on the learning goal and the context. Then, the Process Language layer must take into account both the decomposition of learning goals and the context (user profile). Once this decomposition of goals is made, the discovery of the candidate learning objects that fulfil the goals must be triggered, connecting in the LUISA case with the Semantic Web Service Layer.

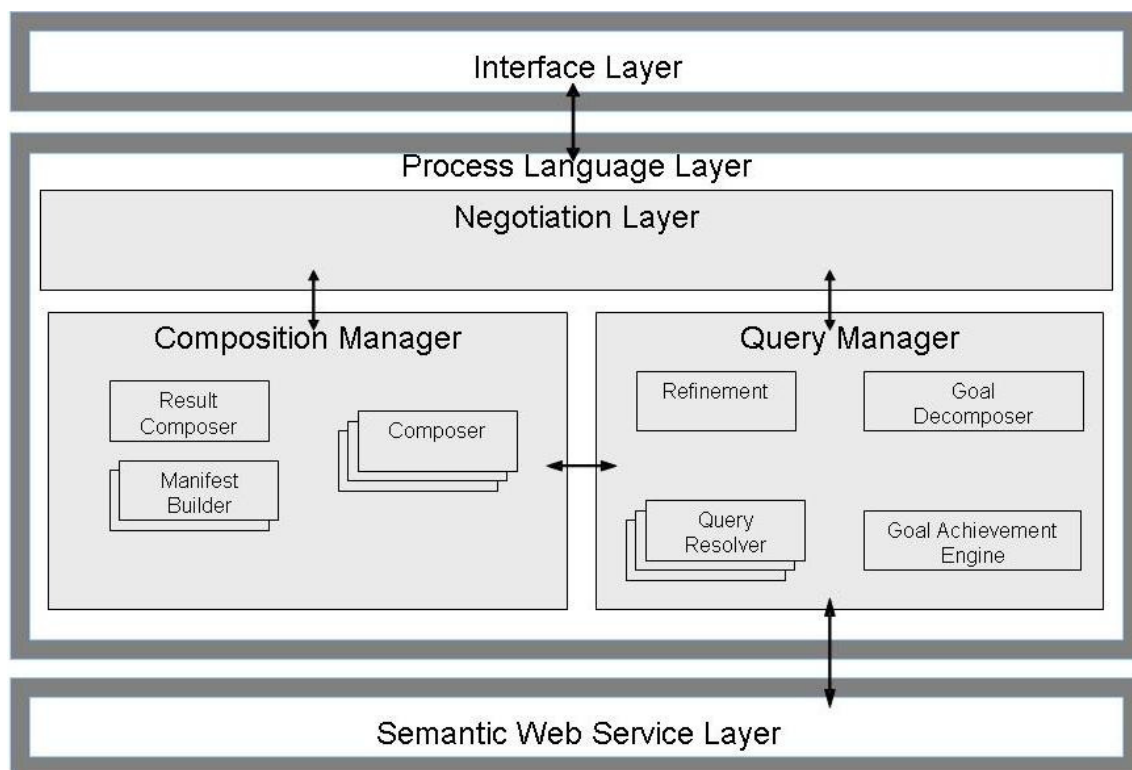
Once the candidate LOs have been identified, a negotiation phase could be necessary. Taking into account the requirements from the case studies there are some situations where the use of a negotiation component would offer an important functionality. As a matter of example, according to the UHP case study requirements the negotiation phase occurs when there is no LO satisfying request constraints. The learning goal could be something like “learner L from UHP requires learning about competency C and discipline D”. Negotiation in this case helps the user to relax constraints:

- If there is no LO for a competency C in a discipline D, the system proposes to select another discipline (with LOs for this competency).
  - In this case the negotiation phase does not need to come back to the end-user, but is able to create a new goal on behalf of the user.
- If a LO is about several target competencies, the user should be able to choose if (s)he accepts to work on more competencies that those requested, and on which ones.
  - This is a real negotiation case that involves the end-user’s feedback on selecting the adequate competencies (s)he is willing to use. This decision can trigger new learning goals.

Taking into account all of these issues, the Process Language Layer provides the relationship between the end-users of the LUISA framework and the Semantic Web Service layer. The main objectives of this layer are the following:

- Manage the interaction between the end-user application and the Semantic Web Service Infrastructure.
- Deal with the negotiation of the provided results to the end-users.
- Implement the infrastructure to easily plug in the rules to that resolve a specific query (learning objective). These rules are based on specific scenarios, so the infrastructure has to deal with the possibility of adding multiple query resolvers.
- Allow the implementation of different composition strategies in a unique learning package. As in the previous case, the infrastructure has to allow an easy plug in of different strategies (Composers).

The following figure shows the Process Language Layer architectural components:



**Fig. 6.** Process Language Layer architectural components

Currently a prototype of the Process Language Layer is under development as a Web Service with methods such as `getLOsByCompetency`, `composeLOs`, etc. This prototype includes a first version of the Query Resolver implementing the

UHP rules, and connection with the Transparency Layer. Methods for retrieving competencies and disciplines dependencies have been provided in collaboration with UAH, accessing to the UHP competency and discipline ontologies.

## 7.1 Negotiation Layer

The Negotiation Layer core allows the communication between the LUISA LMS in the Interface Layer and the rest of the components of the Process Language Layer (Query Manager and Composition Manager). The communication with other components of the Interface Layer, like the Authoring and eLearning applications, although in principle may be handled by the Negotiation Layer it is not the main focus of this component.

The negotiation involves collecting data from the end-user application and dealing with the negotiation of the provided results to the end-users. This negotiation implies verifying the suitability of the user profile to specific learning objects, and assuring the persistence of the session between the Interface Layer and the Process Language Layer.

As the variability of the learning goals can be very high (Learning design based on competencies, competency gaps, field of study, etc.), it is still not clear if LUISA is going to provide a unique implementation of the Negotiation Layer or one reference implementation per case study. The current idea is to define this reference implementation with a clear interface for all methods that the Negotiation Layer will be able to provide.

## 7.2 Query Manager

The Query Manager is in charge of managing the goal (learning objective) provided by the user, decompose it in case it is necessary and invoke the SWS layer to achieve the goals. The results to these invocations are gathered by this component and digested by the appropriate Query Resolver that implements the rules to which the invocation are bound. If the results can be combined automatically in new learning packages, the Query Manager will invoke the Composition Manager to create this package. The interaction with the end-user is always managed through the Negotiation Layer.

The Query Manager is composed by several sub-components:

- **Goal Decomposer:** This component takes a given goal from the user (learning objective) and involves decomposing goals into sub-goals (in case the goal is decomposable). The invocation of the goals is managed by the Query Executor.
- **Goal Achievement Engine:** This component is in charge of the invocation of the goals that will be accomplished by the Semantic Web Service Layer. The results to this execution will be digested by the appropriate Query Resolver.

- **Query Resolver:** The key functionality of this component is processing the rules that resolve a specific query (goal or composition of sub-goals), verifying/negotiating the obtained results in coordination with the Negotiation Layer, eventually invoking a goal again using the Goal Achievement Engine. It is important to note that the behavior of this component changes according to different contexts and scenarios (i.e. domains). For this reason we expect multiple “instances” of this component that can be – manually (i.e. from the user) or automatically - selected.
- **Refinement components:** Other modules that can be part of this component deal with some aspects of the refinement of the Learning Objects such as prioritization, refinement of the results, filtering, ranking, etc.

### 7.3 Composition Manager

The Composition Manager is in charge of creating new composed Learning Objects in a unique package. This package will be stored as a new LO in the LUISA LOMR and send back to the Negotiation Layer or the Query Manager. The management of these LOs (creation or deletion of LOs) will be handled by the Result Composer component.

Composition of Los is not an easy task. Learning object composition is the process of combining several LOs into a higher level instructional unit that fulfils specific learning goals under concrete contextual circumstances. Composition requires selection as a constituent process. Nonetheless, composition imposes additional constraints coming from the fact that the LOs retrieved from different sub-goals can not be joined together. For instance, due to incompatible style designs or even to inconsistency in the pedagogical approach or level of description. There are a lot of different strategies, algorithms and possibilities for learning object composition [18], [19], [20]. The idea of the Composition Manager is then to offer a unique interface for composition of LOs, but giving room to different concrete implementations of the algorithm for this automation. As in the case of the Query Resolver, we expect multiple “instances” of the Result Composer component that can be manually or automatically selected.

Thus, a set of different composers can be implemented following different strategies. For instance the authoring user would be able, using the Negotiation Layer, to create a SCORM package and manifest by using a SCORM Composer along with a SCORM Manifest Builder. The obtained SCORM package is given back to the negotiation layer and then to the end-user application.

## 8 CONCLUSION AND OUTLOOK

In this document, we described the work within the LUISA project related to task 2.1. “SWS based Infrastructure for eLearning Applications”, task 2.3 “Linking WSMO enhanced Ontologies to Learning Object Standards”, and task 2.4 “WSMO Process Language”. We provided a first prototype of a SWS based

infrastructure for eLearning (Task 2.2) which integrates the main components of the LUISA project. Furthermore, we introduced a conceptual framework to map between WSMO SWS and eLearning standards (Task 2.3) as well as an ontology stack aimed at implementing this framework. Besides that, we introduced an ontology as well as the architectural components needed to support learning processes (Task 2.4).

Our approach - the support of learning objectives based on a dynamic invocation of SWS - follows an innovative approach and is distinctive to the current state of the art in this area. By using Semantic Web as well as SWS technology our approach overcomes the limitations described in Section 2 and supports a high level of standard-compliance and re-usability within existing runtime environments, since it is fundamentally based on compliance with current eLearning metadata standards. In particular, the following contributions should be taken into account:

- Dynamic adaptation to specific learning contexts at runtime
- Automatic allocation of learning resources based on comprehensive semantics
- High reusability across learning contexts
- Platform- and standard-independence
- Reuse and integration of available learning resources
- Decrease of development costs

Since our framework is developed only in parts currently, next steps have to be concerned with the implementation of complete ontological representations of the introduced semantic layers as well as of current eLearning metadata standards and their mappings. Nevertheless, the availability of appropriate web services aimed at supporting specific process objectives has to be perceived as an important prerequisite for developing SWS based applications. To provide more valid quantifications of the benefits we are expecting from our approach, we are going to provide further examples based on case studies to illustrate the formalized measurements introduced in the sections above.

Finally, the integration of the work within the LUISA work package 2 with the work of related work packages is an ongoing and important task. In particular, next steps will be related to implement usage scenarios of our application based on the use cases described in work packages 6 and 7.



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