DELIVERABLE

LEARNING COMPASS

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O1/A2: Information model for Learning Opportunities

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1 INTRODUCTION

1.1 Purpose

The main target of intellectual output "*O1: Lifelong Learning Opportunity and Pathway models„* is the extension of the *EN15982 MLO European Standard* with information on learning outcomes and competences towards the development of a metadata structure to represent and describe *HEI Learning Opportunities*.

The workplan towards this purpose includes the following steps:

1. Initially, we are going to *review and report on existing* organisational and technological structures for learning opportunity exploration (Ploteus, the XCRI implementation, etc.) focusing on the underlying information model;
2. Next, we are going to focus on the creation of an *information model* for representing metadata concerning lifelong learning opportunities in the ICT domain, documented in a way easily transferable and adopted to other domains. The information model and associated metadata schema will specify how a solid infrastructure can be deployed for the management, publishing, and exploration of lifelong learning opportunities, as well as pathway planning, thus facilitating personal development and enhancement of employability.
3. Finally, a *methodology* for describing learning opportunities in such a way that they are reusable and sharable across different domains, educational levels and contexts will be described. This methodology will describe a set of "design patterns„ for the creation and structure of metadata, as well as a quality-controlled process for creating new patterns and further evolve existing ones.

In order to effectively execute these steps, two sets of activities have been planned:

A1. *Analysis of existing Learning Opportunities schemes:* To date, various national as well as European-level efforts have been made to facilitate students, job seekers, workers, parents, guidance counsellors, and educators to find out information about studying in Europe. This activity's purpose is to present an extensive study of the existing platforms, their capabilities and merits, as well as their limitations.

A2. *Development of an information model for representing Learning Opportunities:* This activity is focused on the design, proposition and provision of an information model for representing learning opportunities, based on the insight of existing systems, as well as the European standards for representing learning opportunities. This model, while being generic, draws upon the specificalities of the ICT domain, and shall drive the design of an online platform to manage, publish and allow exploration of all information related learning opportunities by all interested parties.

The purpose of this document, titled "Information model for Learning Opportunities", is to document the results of the second activity of the first intellectual output of the project (O1/A2).

1.2 Methodology

The information model for capturing the data and metadata related to Learning Opportunities presented in this document builds upon the outcomes of the first activity of the project's first intellectual output ("*O1/A1: Analysis of existing Learning Opportunities schemes*"), as well as on recent developments in the domain of standardisation and modelling of relevant information structures, the most important being:

- "MLO" European Standard for Metadata for Learning Outcomes [11];
- "INLOC" CEN's draft specification for Integrating Learning Outcomes and Competences [10]; and
- "XCRI-CAP" UK's specification for eXchaning Course Related Information – Course Advertising Profile [3].

All these structures have been thoroughly described and discussed in the "O1/A1" intellectual output, along with more details about related information systems and models.

The methodology for the development of the COMPASS information model includes the following activities:

1. Design of an information model for capturing all data and metadata related to lifelong learning opportunities focusing in the ICT domain;
2. Development of an associated metadata schema;
3. Use of the information model and the metadata schema for specification of an software platform that shall enable:
    - the management and publishing of lifelong learning opportunities, with an emphasis on a linked-data approach for the definition of related learning outcomes and competences;
    - the development of services for exploration of those opportunities; and
    - the development of services for "pathway planning" for personal development, based on matching of intended learning outcomes and competences to existing learning opportunities that have been published in any of the federated information systems.

1.3 Audience

This document is primarily targeted towards the partner organisations and the technical development team of COMPASS that will be involved in the design, integration, implementation and content population of the online services. It is also intended for the broader COMPASS consortium (including associated partners), as an interoperability instrument for sharing and exchanging information about learning opportunities, combined with associated descriptions of expected learning outcomes and competences, within the envisioned federation of repositories and related software systems. In addition, the document's audience includes practitioners and researchers working on related projects, as well as potential future consortia, organisations or

individuals interested in adapting or reusing the COMPASS metadata architecture, as a whole or partially reusing some of its constituents.

1.4 Structure

This report is structured in five chapters:

- Chapter 1 “Introduction” holds introductory information;
- Chapter 2 “Metadata Architecture” describes the overall architecture for the design and implementation of the COMPASS information model;
- Chapter 3 “The COMPASS Information Model” presents the information model;
- Chapter 4 “The COMPASS Metadata Schema” presents the associated metadata schema;
- Chapter 5 “Roadmap” provides insight about next work and expected evolution of the information model and the associated metadata schema during the lifecycle of the COMPASS project and above;
- Chapter 6 “References” holds references to relevant sources of information.

2 METADATA ARCHITECTURE

COMPASS aims at deploying an advanced, community-focused integrated platform for the retrieval of relevant learning opportunities and data that will facilitate students and life-long learners to formulate their learning pathways, aligned to their career requirements and goals. Furthermore, COMPASS' s federated approach will stimulate the enhancement of information seeking with extended criteria, the most important being those related to formal definitions of learning outcomes and competences.

In order to address the needs of COMPASS stakeholders and move towards the COMPASS vision, metadata, as a means for describing learning opportunities, figures a key enabler and catalyst for the implementation of the related services. For repositories, metadata is a valuable, core asset that needs to be curated, managed, validated, quality controlled, and, last but not least, exchanged and shared with other systems. Internally, a repository or other metadata-rich system may only take into account and address a limited set of specific and custom requirements. However, when it comes to the efficient and reliable sharing and exchange of cross-repository content, well-designed, domain specific and agreed upon metadata specifications become a crucial consideration [1].

The next paragraphs of this section document the COMPASS metadata architecture and the associated process towards the definition of the COMPASS Metadata Schema.

2.1 Metadata key concepts

According to the World Wide Web Consortium (W3C) [27]:

Metadata is structured schema about data.

Work on metadata was initially part of W3C's Technology and Society Domain[1]. The W3C Metadata Activity was replaced with the W3C Semantic Web Activity[1] when the latter was chartered in February, 2001. Work conducted under the Semantic Web Activity has ended on October 2013. It is now continued on the W3C Data Activity[1].

The use of metadata supports methods to identify, authenticate, describe, locate and manage resources in a precise and consistence way that meets business, accountability, and archival requirements [17]. The key concepts about metadata are thoroughly described in two documents by the International Standardization Organisation (ISO).

- ISO 23081-1, which provides (a) the principles behind schemas and (b) the purposes of metadata;
- ISO/TS 23081-2, which describes (a) how schemas are constructed and maintained and (b) suggestions for elements and aggregations.

[1] http://www.w3.org/TandS, http://www.w3.org/2001/sw, http://www.w3.org/2013/data

The key concepts related to metadata are the following:

- **Metadata schema**. A schema is a logical plan showing the relationships between metadata elements, normally through establishing rules for the use and management of metadata specifically as regards the semantics, the syntax and the optionality (obligation level) of values [20].
- **Application profile:** An application profile delineates the use of metadata elements declared in an element set. While an element set establishes concepts, as expressed via metadata elements, and focuses on the semantics or meanings of those elements, an application profile goes further and adds business rules and guidelines on the use of the elements. It identifies element obligations and constraints, and provides comments and examples to assist in the understanding of the elements. Application profiles may include elements integrated from one or more element sets thus allowing a given application to meet its functional requirements [12].

  NOTE: *this definition has a different emphasis to that used in the Dublin Core community. For that community an application profile is the way someone (it could be anyone or any organisation) sets out their conceptual view of their use of metadata properties, what vocabularies to use, etc. Although it is about a specific application of metadata for a particular purpose, is still primarily a conceptualisation of metadata use. Once the application profile is done, it is possible to develop a machine readable schema, which is merely a way of expressing the application profile in a way that is useful at the implementation level.*
- **Encoding scheme:** An encoding scheme is defined as a controlled list of all the acceptable values in natural language and/or as a syntax-encoded text string designed for machine processing [18]. It Includes rules/formats for entering data such as dates, names of people, etc.
- **Crosswalk:** A crosswalk is defined as a specification for mapping one metadata standard to another. Crosswalks can also occur between schemas and application profiles.
- **Harmonization:** The process of enabling consistency across metadata standards. Harmonization of metadata standards is essential to the successful development of crosswalks between metadata standards. Harmonization results in the ability to create and maintain only one set of metadata, and to map the metadata to any number of related metadata standards [26]. The use of harmonization vastly simplifies the development, implementation and deployment of related metadata standards through the use of common terminology, methods and processes.

2.2 Re-use of existing standards and specifications

The key question when implementing a metadata initiative is this [17]: *"Is it necessary to create a new metadata schema, or are there already existing metadata schemas which can be adapted for use?"* In general, the fewer metadata schemas, the better. We use standards to improve interoperability and to reduce unnecessary variation. It is better and easier to adopt something that already exists, is well modelled, and comprehensively supported.

Given the fact that metadata's key rationale is sharing, exchange and inter-connectivity of diverse systems, it is evident that efforts to develop metadata specifications should start off by reviewing existing, mature standards studying their underlying models, and by investigating their interoperability features and support of reuse. Indeed, most metadata specifications inherently support their extensibility and adaptation so as to address the needs of specific communities and applications.

The re-use of mature metadata standards and the specification of domain-specific metadata profiles for describing research resources and related entities is one of the key aspects of the COMPASS project. Metadata need to be designed in a way that they reflect important domain-specific aspects of resources to users, for instance learning outcomes and/or competences related to a learning opportunity. Devising and adopting a consistent metadata approach based on consolidated standards and semantics technology, while at the same time modelling particular community features, will enable the formulation of semantically-rich representations of resources, capable of supporting the development of the envisaged services for the access to, exchange and sharing of learning opportunities.

In addition, such an approach for interoperable metadata specification, will ensure interoperability among diverse information systems of Higher Education Institutes (HEIs) as well as systems of related organisations (employment agencies, seminar providers, international organisations, industry, etc.), thus enabling providers to federate with the COMPASS platform, and allow the efficient integration and implementation of seamless, transparent and user-friendly services. To this end, this deliverable documents the suggested COMPASS metadata architecture.

2.3 Metadata architecture

According to Duval et al. [9], a metadata architecture is the *"coherent collection of enabling technologies, element sets, and standards of practice that collectively support the creation, management and exchange of interoperable metadata."* Indeed, the COMPASS metadata architecture associates a set of different components, ranging from standards and specifications to guidelines and procedures. The main component of the metadata architecture, as this is described in the following paragraphs, is the COMPASS Metadata Schema. The COMPASS metadata architecture aspires to address the following key objectives:

- Formulate a conceptual framework for the common understanding of the important constituents of the information model for describing learning opportunities against related learning outcomes and competences. The framework will support the creation of a sustainable information structure by identifying and clearly defining the entities of interest to stakeholders, the attributes of each entity, and the types of relationships that operate between entities;
- Provide an interoperability infrastructure for COMPASS metadata creators to produce and for content providers to expose their metadata using a commonly agreed and quality-controlled format;
- Serve as the basis for the development of related, advanced services;
- Support the deployment and operation of the COMPASS platform, i.e. the aggregation of complete and quality metadata.

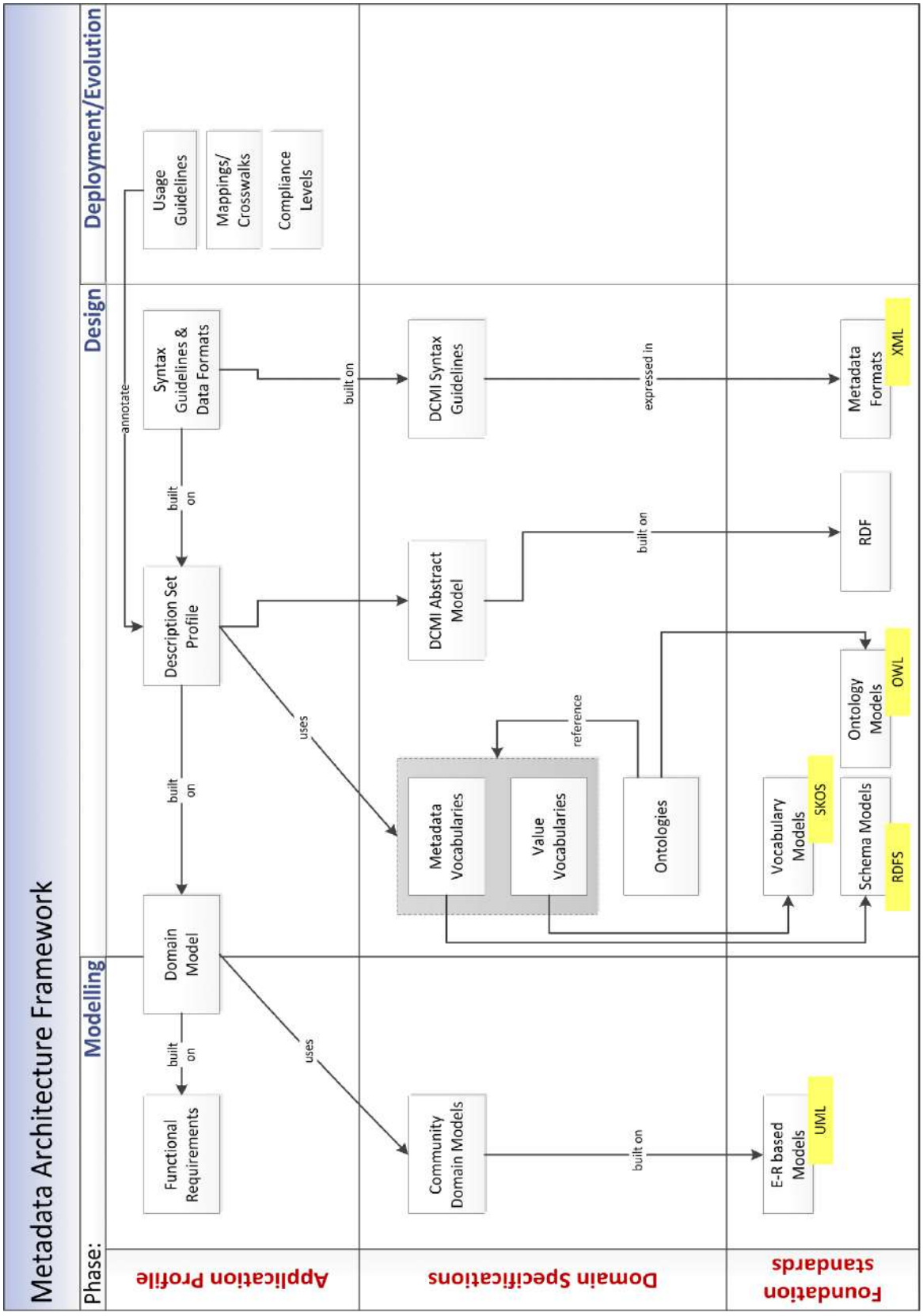

Figure 1: DCAM-based Metadata Architecture

In order to take the step from raw data to metadata, a metadata specification must, besides the syntax specification, also define an interpretation of the syntax in terms of information about a thing [25]. This means that a metadata architecture should be based upon an abstract model which defines a mapping from the concrete syntax to some form of meaning of the metadata.

Abstract models make it possible for a single specification, even if expressed in several different formats, to be understood in a uniform way by users and applications. Existing metadata standards either rely on hierarchical models (e.g. IEEE LOM) or entity-relationship based models (e.g. RDF and Dublin Core).

The COMPASS vision for describing, managing, accessing, exchanging and sharing learning opportunities in the Web 2.0 environment calls for the design of flexible, extensible, "loose"[2] and self-describing metadata that integrate with a semantic web of linked data. On this basis, COMPASS aims to produce a sustainable and adaptable metadata infrastructure based on the resource-property-value model, moving from the resource-legacy approach representing an information package, to focusing on the component parts of a resource description.

Towards this end, our recommendation for the COMPASS Metadata Architecture draws on the semantic-web based Dublin Core Abstract Model (DCAM) and the Singapore Framework (SF) for building Application Profiles (APs). Figure 1 illustrates the proposed DCAM-based metadata architecture and its key component the COMPASS Metadata Schema. This architecture reuses and refines the related DC specifications, following a layered approach:

- The bottom layer holds the foundation standards, i.e. the standards, specifications, schemas, etc., that have been selected for the representation of the metadata architecture's constituents.
- The middle layer holds the domain standards, i.e. the specific selection of ontologies, vocabularies, models, etc. according to their relevance to the COMPASS domain and the suitability to address the design and functional requirements of the identified stakeholders.
- The top layer, being in fact the key component of the metadata architecture, is the metadata schema, upon the instantiation of which actual implementations will be based.

The remaining paragraphs of this section provide insight on the constituents of the metadata schema in terms of a formal, four-phased development process.

2.4 Metadata schemas and application profiles

Application profiling of metadata specifications refers to specific deployments of standards or specifications in order to support the requirements of a particular application, function, community or context, and the term Metadata Application Profile has been applied over the last decade to describe this tailoring of metadata standards by their implementers. In particular, application profiles have been used to ensure the interoperability of metadata schemas, and as an extension, provide an opportunity for collaboration.

[2] decoupled from the information described

In a Dublin Core (DC) application profile, the terms referenced are terms of the type described by the Dublin Core Abstract Model, i.e. a Dublin Core application profile describes, for some class of metadata descriptions, which properties are referenced in statements and how the use of those properties may be constrained. The DC notion of the application profile imposes no limitations on whether those properties or encoding schemes are defined and managed by the Dublin Core Metadata Initiative (DCMI) or by some agency: the key requirement is that the terms referred to in a DC application profile [25]. In particular, the Dublin Core Application Profile (DCAP) encourages interoperability, harmonization of usage and convergence between DC compliant metadata sets, through a set of guidelines for the structure and content of DC-based application profiles. The DCAP guidelines stress the importance of human-readable descriptions, and therefore expressing schemas as text documents is emphasized. However, the guidelines do give recommendations for documenting application profiles in more formal and controlled forms, as RDF and XML.

The requirements of an application profile were initially described as [24]:

- A definition of entity classes described by the application profile and an identification of the functions that the schema is intended to support.
- A declaration of what elements are included in the schema and details about their semantics, rules for their usage, and allowable value data types.
- Details about which controlled vocabularies would be used to restrict the allowable values for particular fields.
- Human readable information about the schema and guidelines for use.

The DCMI Singapore Framework (SF) offers the following definition of an application profile: A Dublin Core Abstract Model (DCAM)-conformant Application Profile is a packet of documentation that consists of:

- Functional requirements, which describe the functions that an application profile is intended to support, plus functions that are not within the project's scope. (Mandatory)
- Domain model, which defines the basic entities described by the application profile and their relationships and defines a basic scope. (Mandatory)
- Description Set Profile, which defines a set of metadata records that are valid instances of an application profile. (Mandatory)
- Usage guidelines, which describe how to apply the application profile. (Optional)
- Encoding syntax guidelines which describe any application profile-specific syntaxes and/or guidelines. (Optional)

2.5 A process model for the COMPASS metadata schema

Building and maintaining metadata specifications or application profiles, in its simplest form involves the process of selecting and combining metadata elements from existing namespaces, possibly extending the base element vocabularies with locally defined elements, and choosing a

set of useful value vocabularies for use with these elements, in order to accommodate a purpose that is not sufficiently met by one metadata schema [26]. However, building complete and sustainable metadata schemas and / or application profiles should entail a more advanced design and documentation process, including the definition of requirements which metadata shall need to address as well as the modelling of the target domain. Implementers can then be safe in the knowledge that the assembled whole can be interpreted correctly by independently designed software systems. Achieving interoperable infrastructure requires the development of common vocabularies and metadata frameworks as the basis for description, discovery, and integration of the services, together with the use of domain-specific knowledge for problem solving in order to compose services.

Such a complex and demanding task requires a well-defined process which, apart from the technical development issues, puts emphasis on the adopting communities, namely the creators, curators and consumers of metadata, the application developers, the profile authors, etc. [2]. On this basis, the COMPASS metadata architecture team adopted the DCMI SF recommendations and employed a well defined process for the definition,documentation, support, and evolution of the COMPASS information model and related metadata schema. This process has been modelled using a formal Business Process Modellin Notation (BPMN), as presented in Figure 2, and shall drive the evolution of the metadata schema throughout the project's lifecycle and beyond.

The activities of the four-phased process lifecycle are described in Table 2.1. This controlled lifecycle for the development of a full-fledged metadata specification, including definition of concrete tasks and expected outputs, safeguards the adherence to and further refinement of the Singapore Framework's mandates.

It must be noted that the proposed formal process for developing APs, does not suggest a one-way,waterfall-like, lifecycle, but rather an iterative approach, allowing for controlled interaction between the four phases. Moreover this process mainly follows a top-down approach, in accordance with the inherent DCAP development methodology. However, specific tasks within the process build upon a bottom-up approach, in the sense that stakeholders' existing and applied metadata practices need to be analysed and taken into consideration. Furthermore, in many cases provisional metadata solutions need to be devised in order to support interoperability and harmonization related experiments. Although this may seem like a diverging activity, it often proves most valuable for revealing important issues regarding the conceived usefulness, appropriateness and comprehensiveness of the designed AP. As pinpointed in (Greenberg et al, 2009), *"the two approaches are not necessarily at odds and could be instead viewed as two renderings of the same intellectual work along a continuum"*.

In accordance with the proposed process, the next sections focus on the domain analysis and functional requirements elicitation as well as on the specification of the COMPASS domain model.

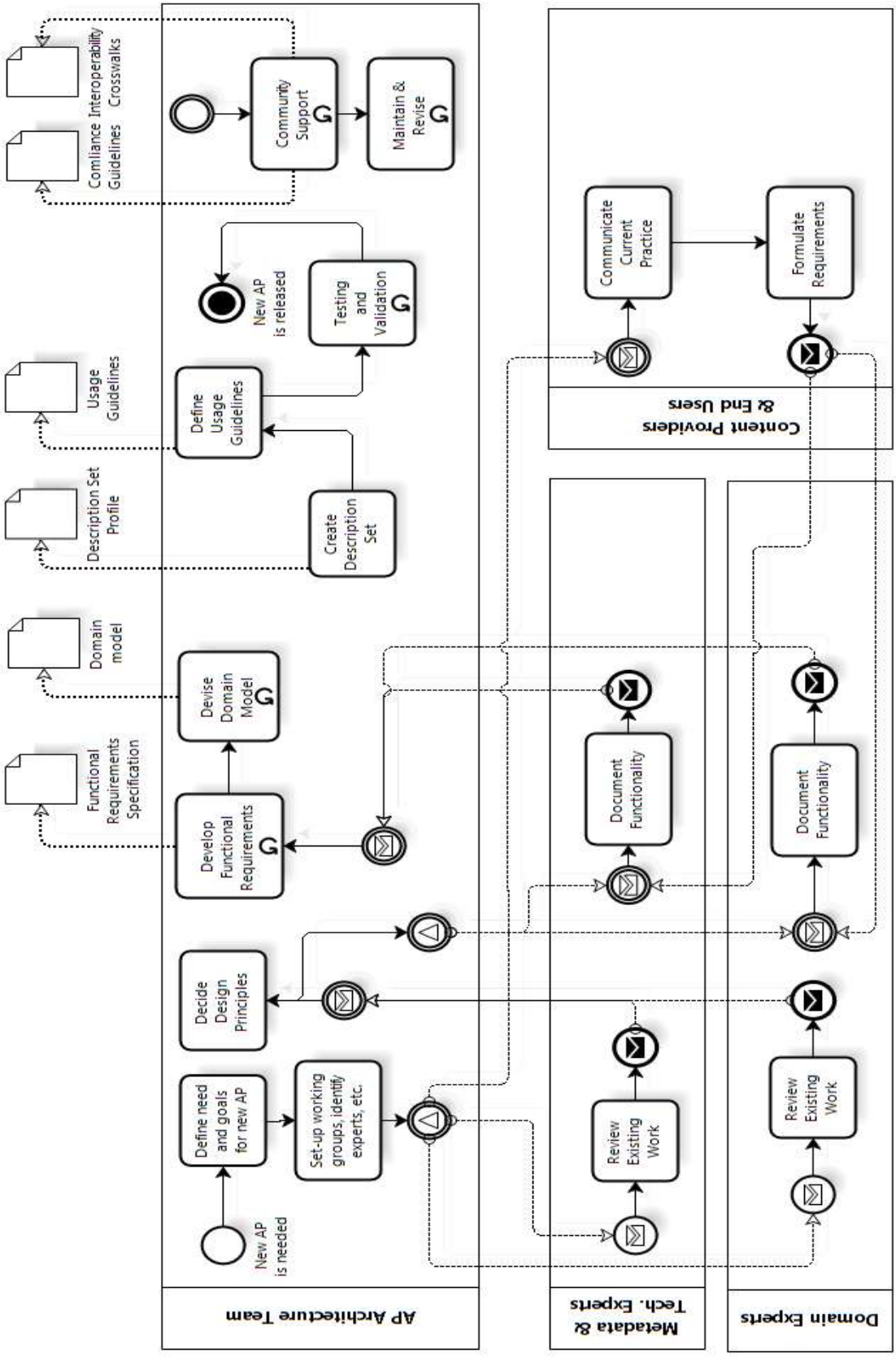

Figure 2: BPMN model of the COMPASS AP development and evolution process

Table 1: Phases and tasks of the COMPASS metadata schema development process

Phase 1. Domain analysis and requirements specification
Set up working groups to involve technical and domain metadata experts and engage the stakeholder communities to ensure maximum completeness in the identification of requirements and foment community uptake.
Organize activities on review of related work on existing related mature metadata standards and schemes and their use cases. Analyse current practices within stakeholder communities.
Orchestrate requirements elicitation activities for identifying what kinds of functionality the application profile is intended to support.
Document the specification of the design and functional requirements.
Phase 2. Metadata Design
Devise a domain model by means of a UML/entity-relationship diagram.
Elaborate the detailed description of the metadata properties of the application profile (Description Set Profile) corresponding to the model.
Foster activities for the development of required community-specific vocabularies.
Produce initial set of usage guidelines.
Organize review and consensus activities.
Phase 3. Testing and validation
Conduct self and invited testing.
Collect examples and develop a set of best practices guidelines for each of the properties in the metadata schema.
Organize expert and community review of whole specification (metadata schema, application profile, vocabularies, best practices, etc.)
Arrange for compatibility testing.
Release the final specification of the metadata schema and application profile(s).
Phase 4. Metadata deployment, evolution and community support
Develop compliance guidelines.
Produce metadata mappings/crosswalks to allow interoperability.
Maintain and revise the metadata schema and associated application profile(s) according to evaluation activity results.

2.6 Design requirements of the COMPASS metadata schema

One of the main targets of the domain analysis activities carried out and described in the first activity of Intellectual Output O1 "Lifelong Learning Opportunity and Pathway models", has been to guide the elicitation and formulation of the requirements which should be addressed by the COMPASS metadata schema. Through these activities the content providers, metadata and

technical teams had the opportunity to work on and refine the aspects of COMPASS related to the platform functionality and learning opportunity advertising services, encompassing also key issues regarding content description, integration and harmonization, which have a direct influence on the design of metadata.

In general the COMPASS metadata schema needs to support the following high-level functionality:

- Facilitate the description, sharing and re-use of learning opportunites, learning outcomes and competences within open access repositories;
- Support the discovery of learning opportunities;
- Support the matching of learning opportunities to specific learning outcomes and/or competences;
- Support the identification and classification of learning opportunities using existing ontologies and taxonomies;
- Enable the semantic interconnection of resources by supporting the exposure of metadata in linked data formats;
- Serve as an interchange format between various repositories using different metadata standards and formats;
- Use for harvesting metadata from diverse source repositories through a quality controlled process into curated "refaratories";

The following paragraphs provide a detailed description of the elicited and identified requirements associated to the high level metadata design principles, mainly reflecting the nature and characteristics of the resulting metadata schema.

2.6.1 Rich metadata re-using existing (standard) models

In current practice, harvesting or cross-searching multiple repositories is faced with a number of metadata-related issues. One major issue is that the MLO schemas' metadata elements do not offer the level of detail corresponding to the COMPASS domain requirements. A richer set of metadata would enable aggregators to offer services built upon repository metadata and content.

Design Requirement(s):

[DR.01]	The COMPASS XXX AP shall provide a richer set of metadata than is currently possible with MLO

2.6.2 Metadata as linked data

More and more resource data sets, controlled vocabularies and authority files are becoming available as Linked Data.

Design Requirement(s):

[DR.02]	The COMPASS XXX AP shall make use of a linked data compatible syntax;

[DR.03]	The COMPASS XXX AP shall support a domain model which allows joining data from other domains;
[DR.04]	The COMPASS XXX AP shall make use of metadata terms supporting the usage of identifiers for citation and linking.

2.6.3 Consistent metadata

An aggregator is setting up a search service whereby they can provide cross search, browse and filter capability across metadata harvested using OAI-PMH from the XXXX provider repositories implemented on different software platforms. The aggregator wants to ensure that the data being harvested into the service is consistent, both in terms of the metadata elements used and the contents of those elements.

Design Requirement(s):

[DR.05]	The COMPASS XXX AP shall facilitate creation and sharing of consistent metadata.

2.6.4 Extensibility

The current scope of the COMPASS XXXX AP work has a narrow definition. If the profile gains community acceptance, its users may wish to augment it with more expressiveness in terms of entities, attributes and relationships that fall under the broader remit of research processes and context. Other application profiles may exist for this purpose, and it would be beneficial to the community if the approaches taken by this and other application profiles were mutually supportive and could be successfully mapped.

Design Requirement(s):

[DR.06]	The COMPASS XXX AP shall allowfor richer functionality via extensions

2.6.5 Added-value services

The COMPASS XXX AP should support advanced services such as document lifecycles, scientific research methods and alike added value services.

Design Requirement(s):

[DR.07]	The COMPASS XXX AP shall be sustainable, extensible and robust enough to support future added-value services.

2.7 Terms and definitions

- **Aggregator:** A system (application or service) that collates descriptions of Learning Opportunities from multiple Learning Opportunity Providers in order to offer additional functionality to users based on those descriptions, for example to search, browse, and compare Learning Opportunities.
- **Provider:** A party (person or organisation) that offers Learning Opportunities. Synonymous with Learning Opportunity Provider.
- **Resource:** Anything that might be identified. Familiar examples include an electronic document, an image, a service. Attention is drawn to W3C-RDFS for the detailed definition of this term. Class: A group containing members that have attributes, behaviours, relationships or semantics in common. Attention is drawn to W3C-RDFS for the detailed definition of this term.
- **Property:** A specific aspect, characteristic, attribute, or relation used to describe resources. Attention is drawn to W3C-RDFS for the detailed definition of this term.
- **Range:** The range of values that may be used for a property. Attention is drawn to W3C-RDFS for the detailed definition of this term.
- **Domain:** The class of resource to which statements using a property may be made. Attention is drawn to W3C-RDFS for the detailed definition of this term.
- **Sub Property Of:** The superclass of a property. Attention is drawn to W3C-RDFS for the detailed definition of this term.
- **Sub Class Of:** The superclass of a class. Attention is drawn to W3C-RDFS for the detailed definition of this term.
- **Literal:** A literal value for a property defined within a statement; this may be a plain literal value (such as a string and language term) or a typed literal value (such as a value and data type specification identifier). Attention is drawn to W3C-RDFS for the detailed definition of this term.
- **Statement:** A combination of a property and a value specified for a resource.
- **URI:** A uniform resource identifier, as defined by IETF-RFC2396.

3 THE COMPASS INFORMATION MODEL

A core activity for the specification of the COMPASS metadata schema and application profile has been the definition of the COMPASS information model for describing learning opportunities of Higher Education Institutes (HEIs). As mentioned already, the information model is based on the *EN15982 MLO European Standard* [11], which it extends with information on learning outcomes and competences. The extension of MLO is itself based on *InLOC*, the draft specification of CEN for *Integrating Learning Outcomes and Competences* [10].

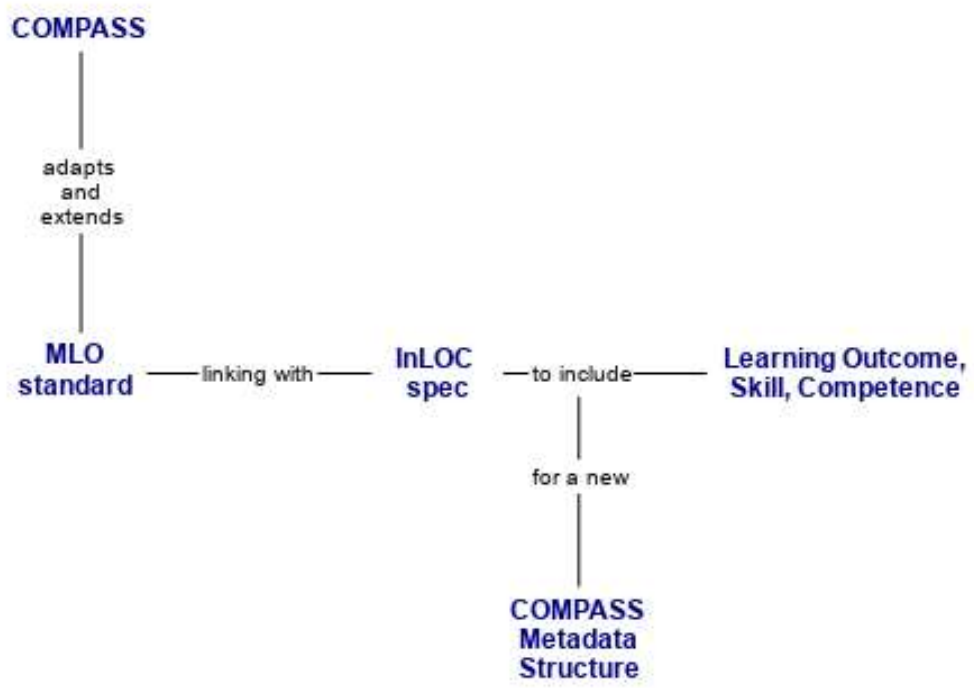

Figure 3: The COMPASS model – extending existing specifications and standards

The information model, as presented in Figure 4, contains two abstract classes and several classes for each of the entities of the model. The definition of the classes, their attributes and associated entities are described in the following paragraphs.

3.1 Generic Metadata

The **GenericMetadata** class (abstract), holds the common attributes of all attributes of the entities related with a learning opportunity:

- identifier: the unique identifier, according to a specific encoding scheme.
- uri: the unified resource identifier (URI) for the entity's web page .
- contributor: the details of the person or organisation who has contributed the information of the entity.
- date: the date of the contribution.

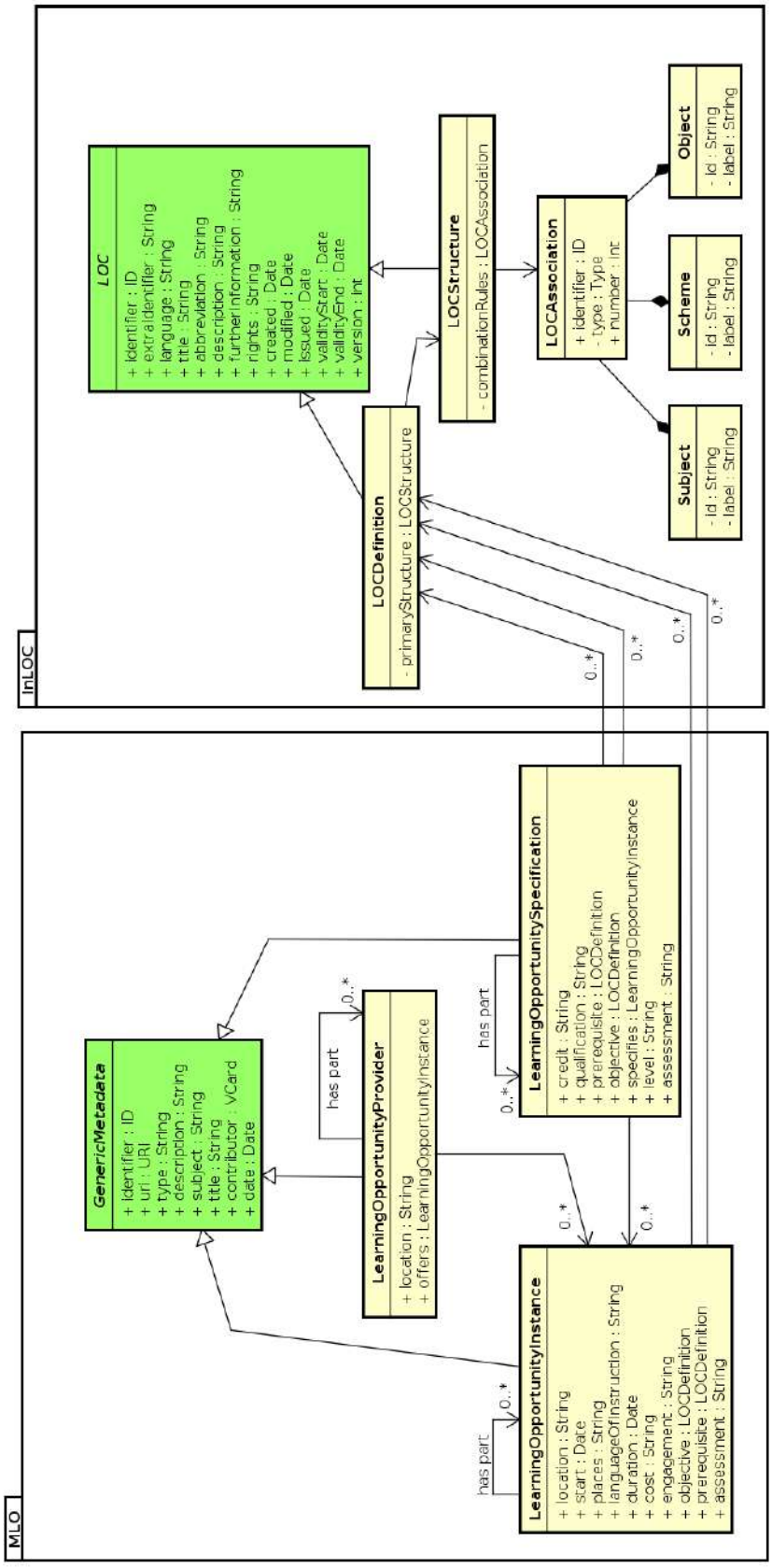

Figure 4: The COMPASS Information Model

- title: the title of the entity.
- description: a description of the entity.
- subject: the subject of the entity.
- type: the type of the entity.

3.2 Learning Opportunity Provider

The **LearningOpportunityProvider (LOP)** class, which extends the *GenericMetadata* class, holds information about the organisation (educational institute) that provides a learning opportunity. It holds all attributes of the *GenericMetadata* abstract class along with one more attribute:

- location: the geographic location of the educational institute.

A LOP entity can be related to other entities through the following relations:

- *hasPart*: used to relate a LOP entity (parent) with one or more LOP entities that are its parts (members).
- *offers*: used to relate the LOP entity with all entities representing the learning opportunities that it offers.

3.3 Learning Opportunity Specification

The **LearningOpportunitySpecification (LOS)** class, which extends the GenericMetadata class, holds the information about a learning opportunity specification, i.e. the overall description of the learning opportunity (not a specific offering). It holds all attributes of the GenericMetadata abstract class along with four more attributes:

- credit: an account of the credits according to a specified system that can be obtained from completion of a Learning Opportunity.
- qualification: the status awarded to or conferred on a learner (note: Many formal learning opportunities are designed to prepare learners for the assessment that may lead to an awarding body awarding them a qualification).
- level: an account of the education level of the Learning Opportunity.
- assessment: the broad approach to assessment used in the Learning Opportunity.

A LOS entity can be related to other entities through the following relations:

- *hasPart*: used to represent hierarchical relations from the parent LOS entity to each direct children LOS entities.
- *specifies:* used to relate a specification of a learning opportunity with all its specific instances.
- *prerequisite*: a reference to prerequisite or entry requirement for accessing the Learning Opportunity.
- *objective*: a reference to an aim or learning objective for the Learning Opportunity.

3.4 Learning Opportunity Instance

The **LearningOpportunityInstance (LOI)** class, which extends the GenericMetadata class, holds all information about a specific offering (instance) of a learning opportunity. t holds all attributes of the GenericMetadata abstract class along with nine more attributes:

- location: the spatial location of the Learning Opportunity.
- start: the date from which the instance of the Learning Opportunity commences.
- duration: the duration of the instance of the Learning Opportunity.
- cost: the cost associated with obtaining access to the instance of the Learning Opportunity.
- languageOfInstruction: the language in which the Learning Opportunity's instance is taught.
- places: a reference to he places available for participants in the Learning Opportunity's instance.
- engagement: the logistical means by which individuals engage in the specific instance of the Learning Opportunity, encompassing temporal, modal and spatial patterns of engagement and attendance.
- assessment: specific description of the approach to assessment used in the Learning Opportunity's instance.

A LOI entity can be related to other entities through the following relations:

- *hasPart*: used to represent hierarchical relations from the parent LOI entity to each direct children LOI entities.
- *prerequisite*: a specific prerequisite or entry requirement for accessing the specific Learning Opportunity's instance, other than the one(s) defined in the respective LOI.
- *objective*: a reference to a specific aim or learning objective for the Learning Opportunity's instance, other than the one(s) defined in the respective LOI.

3.5 Learning Outcome / Competence

The **LearningOutcomeCompetence (LOC)** is an abstract class that doesn't represent any real entity, which holds all generic literal properties that are used for the description of learning outcomes or competences:

- identifier: the unique identifier, according to a specific encoding scheme
- extraIdentifier: any possible alternative identifiers
- language: the language of description
- title: the title of the entity
- abbreviation: an abbreviated version of the title of the entity
- description: a description of the entity
- furtherInformation: a reference to further information about the entity
- rights: a description of the usage rights of the entity

- created: the date of the creation (contribution) of this entity
- modified: the date of modification
- issued: the date that this entity has been issued
- validityStart: the date after which this entity is valid
- validityEnd: the date up to which this entity is valid
- version: an indication about the version of this entity

3.6 LOC Structure

The **LOCStructure** class represents the structure entity and extends the generic properties defined in the LOC abstract class with a number of combination rules (note: *most learning outcome and competence definitions exist as part of a structure or framework*). The class inherits the attributes of LOC and also holds a relation:

- *combinationRules*: a number of references to the LOCAssociation class with the rules for the arrangement of the structure or framework.

3.7 LOC Definition

The **LOCDefinition** class instantiates the specific information about a Learning Outcome or Competence. The class inherits the attributes of the abstract LOC class and holds a relation:

- *primaryStructure*: one or more attributes describing the rules for the arrangement of the primary structure or framework.

3.8 LOC Association

The **LOCAssociation** class denotes relation or compound property of a learning outcome or competence definition or structure. It holds three attributes:

- identifier: the unique identifier, according to a specific encoding scheme
- type: the generic type of relation or compound property as defined by InLOC. Available types and their meaning are:
  - *LOCrel*: the LOCstructure or LOCdefinition related to the subject;
  - *by*: the agent having the given scheme relationship with the subject;
  - *category*: the term classifying the subject with an item in the category scheme;
  - *credit*: the credit scheme level of the subject;
  - *level*: the particular level assigned to the subject;
  - *topic*: the term within the topic scheme vocabulary, taxonomy, ontology, etc.
- number: a decimal number used for describing level and/or credit.

4 THE COMPASS METADATA SCHEMA

The COMPASS Metadata Schema elements and attributes are formally documented using a set of XML Schema Definitions (XSD), the formal W3C's language for XML Schema (XML Schema 1.1[3]). An XML Schema is in fact a language for expressing constraints about XML documents. According to W3C, A Schema can be used:

- to provide a list of elements and attributes in a vocabulary;
- to associate types, such as integer, string, etc., or more specifically such as hatsize, sock_colour, etc., with values found in documents;
- to constrain where elements and attributes can appear, and what can appear inside those elements, such as saying that a chapter title occurs inside a chapter, and that a chapter must consist of a chapter title followed by one or more paragraphs of text;
- to provide documentation that is both human-readable and machine-processable;
- to give a formal description of one or more documents.

Information in schema documents is often used by XML-aware editing systems so that they can offer users the most likely elements to occur at any given location in a document. Checking a document against a Schema is known as validating against that schema; for a DTD, this is just validating, but for any other type of schema the type is mentioned, such as XSD Validation or Relax-NG validation. Validating against a schema is an important component of quality assurance. Since XSD supports associating data types with element and attribute content, it is also used for *data binding*, that is, for software components that read and write XML representations of computer programming-language objects.

A schematic representation of the metadata schema is provided in the figures in Appendix 1.

Listing 1: XSD definition of the COMPASS metadata schema

```
<?xml version="1.0" encoding="UTF-8"?>
<schema
   xmlns="http://purl.org/net/compass"
   xmlns:xml="http://www.w3.org/XML/1998/namespace"
   xmlns:dc="http://purl.org/dc/elements/1.1/"
   xmlns:credit="http://purl.org/net/cm"
   xmlns:xcri="http://xcri.org/profiles/1.2/catalog"
   xmlns:xs="http://www.w3.org/2001/XMLSchema"
   xmlns:dcterms="http://purl.org/dc/terms/"
   xmlns:xhtml="http://www.w3.org/1999/xhtml"

   targetNamespace="http://purl.org/net/compass"
   elementFormDefault="qualified">

   <annotation>
```

[3] https://www.w3.org/XML/Schema

```
    <documentation>
      This is the metadata schema / application profile defined by the
      COMPASS project.

      It is based on the profile of MLO used in XCRI, as revised by Alan Paull.

      The schema implements the MLO information model using a strictly-
      conforming XML binding.
      Conforming bindings should define their own top-level
      classes with extensions.
    </documentation>
  </annotation>

  <import namespace="http://www.w3.org/XML/1998/namespace"
    schemaLocation="http://www.w3.org/2001/xml.xsd" />
  <import namespace="http://purl.org/dc/terms/"
    schemaLocation="http://schema.prospects.ac.uk/xcri/dc/dcterms.xsd" />
  <import namespace="http://purl.org/dc/elements/1.1/"
    schemaLocation="http://schema.prospects.ac.uk/xcri/dc/dc.xsd" />
  <import namespace="http://purl.org/net/cm"
    schemaLocation="http://schema.prospects.ac.uk/xcri/educationalcredit.xsd" />
  <import namespace="http://xcri.org/profiles/1.2/catalog"
    schemaLocation="http://schema.prospects.ac.uk/xcri/xcri_cap_1_2.xsd" />
  <import namespace="http://www.w3.org/1999/xhtml"
    schemaLocation="http://www.w3.org/2002/08/xhtml/xhtml1-strict.xsd" />


  <!-- ranges -->
  <complexType name="Resource">
    <annotation>
      <documentation xml:lang="en">
        This type permits either inclusion of sub-elements (resources)
        or literal text content
      </documentation>
    </annotation>
    <complexContent mixed="true">
      <restriction base="xs:anyType">
        <sequence>
          <any processContents="strict" minOccurs="0"
               maxOccurs="unbounded" />
        </sequence>
      </restriction>
    </complexContent>
  </complexType>
  <complexType name="Association">
    <annotation>
      <documentation xml:lang="en">
        This type permits either inclusion of sub-elements (resources)
        or the use of a literal URI to associate the containing
        resource with a target.
        Text is allowed because mixed="true"
```

```
      </documentation>
    </annotation>
    <complexContent mixed="true">
      <restriction base="xs:anyType">
        <sequence>
          <any namespace="mlo" processContents="strict"
               minOccurs="0" maxOccurs="unbounded" />
        </sequence>
      </restriction>
    </complexContent>
  </complexType>

  <!-- classes -->
  <complexType name="LearningOpportunityObject" abstract="true">
    <sequence>
      <any namespace="http://purl.org/dc/elements/1.1/"
           minOccurs="0" maxOccurs="unbounded" processContents="lax" />
      <element ref="url" minOccurs="0" maxOccurs="unbounded" />
      <element ref="hasPart" minOccurs="0" maxOccurs="unbounded" />
    </sequence>
  </complexType>

  <complexType name="LearningOpportunityProvider">
    <complexContent>
      <extension base="LearningOpportunityObject">
        <sequence>
          <element ref="location" minOccurs="0" maxOccurs="unbounded" />
          <element ref="offers" minOccurs="0" maxOccurs="unbounded" />
        </sequence>
      </extension>
    </complexContent>
  </complexType>

  <complexType name="LearningOpportunitySpecification">
    <complexContent>
      <extension base="LearningOpportunityObject">
        <sequence>
          <element ref="qualification" minOccurs="0" maxOccurs="unbounded" />
          <element ref="credit" minOccurs="0" maxOccurs="unbounded" />
          <element ref="level" minOccurs="0" maxOccurs="unbounded" />
          <element ref="specifies" minOccurs="0" maxOccurs="unbounded" />
        </sequence>
      </extension>
    </complexContent>
  </complexType>

  <complexType name="LearningOpportunityInstance">
    <complexContent>
      <extension base="LearningOpportunityObject">
        <sequence>
          <element ref="location" minOccurs="0" maxOccurs="unbounded" />
```

```
            <element ref="start" minOccurs="0" maxOccurs="unbounded" />
            <element ref="duration" minOccurs="0" maxOccurs="unbounded" />
            <element ref="cost" minOccurs="0" maxOccurs="unbounded" />
            <element ref="languageOfInstruction"
                 minOccurs="0" maxOccurs="unbounded" />
            <element ref="prerequisite" minOccurs="0" maxOccurs="unbounded" />
            <element ref="places" minOccurs="0" maxOccurs="unbounded" />
            <element ref="engagement" minOccurs="0" maxOccurs="unbounded" />
            <element ref="objective" minOccurs="0" maxOccurs="unbounded" />
            <element ref="offeredAt" minOccurs="0" maxOccurs="unbounded" />
          </sequence>
        </extension>
    </complexContent>
</complexType>

<element name="learningOpportunityProvider"
          type="LearningOpportunityProvider" />
<element name="learningOpportunitySpecification"
          type="LearningOpportunitySpecification" />
<element name="learningOpportunityInstance"
          type="LearningOpportunityInstance" />

<!-- associations -->
<element name="offeredAt" type="Association" />
<element name="offers" type="Association" />
<element name="specifies" type="Association" />
<element name="hasPart" type="Association" />
<element name="isPartOf" type="Association" />

<!-- properties -->
<element name="url" type="dc:SimpleLiteral" />
<element name="location" type="locationDType" />
<element name="qualification" type="qualificationDType" />
<element name="credit" type="creditDType" />
<element name="languageOfInstruction" type="dc:SimpleLiteral" />
<element name="level" type="dc:SimpleLiteral" />
<element name="start" type="startDType" />
<element name="duration" type="durationDType" />
<element name="cost" type="dc:SimpleLiteral" />
<element name="prerequisite" type="prerequisiteDType" />
<element name="places" type="Resource" />
<element name="engagement" type="dc:SimpleLiteral" />
<element name="objective" type="objectiveDType" />
<element name="assessment" type="assessmentDType" />


<!-- utility types -->
<simpleType name="dateOrDateTimeDType">
   <union memberTypes="xs:date xs:dateTime xs:gYearMonth" />
</simpleType>
<complexType name="descriptionDType" mixed="true">
```

```
    <sequence>
      <element ref="xhtml:div" minOccurs="0" />
    </sequence>
    <attribute ref="xml:lang" use="optional" />
    <attribute name="href" type="xs:anyURI" use="optional" />
  </complexType>
  <complexType name="vocabularyDType" mixed="true">
    <attribute ref="xml:lang" use="optional" />
    <attribute name="identifier" use="optional" />
  </complexType>
  <complexType name="subjectDType" mixed="true">
    <attribute ref="xml:lang" use="optional" />
    <attribute name="identifier" use="optional" />
  </complexType>
  <complexType name="temporalDType" mixed="true">
    <attribute name="dtf" use="optional" type="dateOrDateTimeDType" />
  </complexType>

  <!-- MLO extensions -->
  <!--<complexType name="qualificationDType" />-->
  <!--<complexType name="creditDType" />-->
  <!--<complexType name="startDType" />-->
  <!--<complexType name="durationDType" />-->
  <!--<complexType name="prerequisiteDType" />-->
  <!--<complexType name="assessmentDType" />-->
  <!--<complexType name="objectiveDType" />-->
  <!--<complexType name="locationDType" />-->

  <complexType name="qualificationDType">
    <complexContent>
      <extension base="qualificationDType">
        <sequence>
          <element ref="dc:identifier" minOccurs="0" maxOccurs="unbounded" />
          <element ref="dc:title" minOccurs="1" maxOccurs="unbounded" />
          <element ref="xcri:abbr" minOccurs="0" maxOccurs="1" />
          <element ref="dc:description" minOccurs="0"
               maxOccurs="unbounded" />
          <element ref="dcterms:educationLevel" minOccurs="0" />
          <element ref="dc:type" minOccurs="0" maxOccurs="1" />
          <element ref="url" minOccurs="0" maxOccurs="1" />
          <element ref="xcri:awardedBy" minOccurs="0" maxOccurs="1" />
          <element ref="xcri:accreditedBy" minOccurs="0" maxOccurs="1" />
        </sequence>
      </extension>
    </complexContent>
  </complexType>

  <complexType name="creditDType">
    <complexContent>
      <extension base="creditDType">
        <sequence>
```

```
            <element ref="credit:scheme" maxOccurs="unbounded" minOccurs="0" />
            <element ref="credit:level" maxOccurs="unbounded" minOccurs="0" />
            <element ref="credit:value" maxOccurs="unbounded" minOccurs="0" />
         </sequence>
      </extension>
   </complexContent>
</complexType>

<complexType name="locationDType">
   <complexContent>
      <extension base="locationDType">
         <sequence>
            <element ref="street" minOccurs="0" />
            <element ref="town" minOccurs="0" />
            <element ref="postcode" minOccurs="0" />
            <element ref="address" minOccurs="0" maxOccurs="unbounded" />
            <element ref="phone" minOccurs="0" />
            <element ref="fax" minOccurs="0" />
            <element ref="email" minOccurs="0" />
            <element ref="url" minOccurs="0" />
         </sequence>
      </extension>
   </complexContent>
</complexType>

<complexType name="startDType" mixed="true">
   <complexContent>
      <extension base="startDType">
         <attribute name="dtf" type="dateOrDateTimeDType" />
      </extension>
   </complexContent>
</complexType>

<complexType name="durationDType" mixed="true">
   <complexContent mixed="true">
      <extension base="durationDType">
         <attribute name="interval" />
      </extension>
   </complexContent>
</complexType>

<complexType name="prerequisiteDType" mixed="true">
   <complexContent>
      <extension base="prerequisiteDType">
         <sequence>
            <element ref="xhtml:div" minOccurs="0" />
         </sequence>
         <attribute ref="xml:lang" use="optional" />
         <attribute name="href" type="xs:anyURI" use="optional" />
      </extension>
   </complexContent>
```

```
</complexType>

<complexType name="assessmentDType" mixed="true">
   <complexContent>
      <extension base="assessmentDType">
         <sequence>
            <element ref="xhtml:div" minOccurs="0" />
         </sequence>
         <attribute ref="xml:lang" use="optional" />
         <attribute name="href" type="xs:anyURI" use="optional" />
      </extension>
   </complexContent>
</complexType>

<complexType name="objectiveDType" mixed="true">
   <complexContent>
      <extension base="objectiveDType">
         <sequence>
            <element ref="xhtml:div" minOccurs="0" />
         </sequence>
         <attribute ref="xml:lang" use="optional" />
         <attribute name="href" type="xs:anyURI" use="optional" />
      </extension>
   </complexContent>
</complexType>

<element name="street" type="xs:string" />
<element name="town" type="xs:string" />
<element name="postcode" type="xs:string" />
<element name="address" type="xs:string" />
<element name="phone" type="xs:string" />
<element name="fax" type="xs:string" />
<element name="email" type="xs:string" />

<complexType name="RTCourseTypeFlag">
   <annotation>
      <documentation>
         Simplistic validation of GP format.
      </documentation>
   </annotation>
   <complexContent>
      <extension base="dc:SimpleLiteral">
         <attribute ref="RT-identifier" />
      </extension>
   </complexContent>
</complexType>
<attribute name="RT-identifier">
   <simpleType>
      <restriction base="xs:string">
         <enumeration value="R" />
         <enumeration value="T" />
```

```
        </restriction>
      </simpleType>
    </attribute>
    <attribute name="identifier" />

</schema>
```

5 CONFORMANCE

Conformance is usually defined as testing to see if an implementation faithfully meets the requirements of a standard or specification [13]. There are many types of testing including testing for performance, robustness, behaviour, functions and interoperability. Although conformance testing may include some of these kinds of tests, it has one fundamental difference – the requirements or criteria for conformance must be specified in the standard or specification. This is usually in a conformance clause or conformance statement, but sometimes some of the criteria can be found in the body of the specification.

5.1 Conforming Instances

A strictly conforming instance is a set of structured information constituted only of objects and statements defined by the classes and properties of this standard and fully qualified refinements of the properties defined in this standard.

A fully qualified refinement is defined for the purpose of conformance as a property that explicitly extends a property defined by this standard. A fully qualified refinement must be capable of being processed according to the semantics of the property it extends.

A conforming instance may contain additional objects and properties.

5.2 Conforming Applications

A conforming provider must be capable of generating and sharing (1) conforming instances , and/or (2) instances that conform to a conforming binding.

A conforming aggregator must be capable of processing (1) conforming instances, and/or (2) instances that conform to a conforming binding.

6 ROADMAP

The COMPASS information model, the COMPASS metadata schema and all related information presented in this document is currently (May 2016) a work in progress. The implementation and evolution model of these instruments, anticipates for an agile process towards building maturity and adopting to the outcomes of the pilot usage, trialling, and feedback collected by direct and indirect users. The following table (Table 2) highlights the main milestones of this process, as adapted by the Project Management handbook of the COMPASS project.

Table 2: Intellectual Outputs, Activities and Milestones

Code	Activity	Type	Due Month
IO 1: Lifelong Learning Opportunity and Pathway models			
O1.A1	Analysis of existing LO schemes	Report	Feb 2016
O1.A2	Information model development for representing LO metadata	Report	Jul 2016
IO 2: Online Services			
O2.A1	Design of online services	Report	Feb 2018
O2.A2	Development of online services	Report	Feb 2017
O2.A3	Delivery and support of online services	Service-Product	Aug 2018
IO 3: Tested and populated online services			
O3.A1	Development of Pilot Testing methodology and evaluation plan	Report	Feb 2017
O3.A2	Population of the online service with the LO from the participating institutes	Service Product	Dec 2017
O3.A3	Internal evaluation of the online services	Report	Dec 2017
O3.A4	Public evaluation of the online services	Report	Jun 2018
IO 4: MOOC on standards-based LO descriptions and the online service			
O4.A1	Development of MOOC - Part 1: Standards-based LO descriptions	Service Product	Sep 2016
O4.A2	Development of MOOC - Part 2: Online service	Service Product	May 2017
IO 5: Recommendations for Policy and Standardization development			
O5.A1	Design and implementation of Policy Suggestions Report	Report	Jun 2018
O5.A2	Design and compilation of Technical Report to Standardization Bodies and Implementers	Report	Aug 2018

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8 ABOUT COMPASS

COMPASS aims at supporting HEIs to implement the necessary reforms in line with the 2011 EU Modernisation Agenda and its priority areas through the improvement of quality and relevance of offered learning opportunities to current and emerging labour market needs, the enhancement of mobility, making LOs more visible and understandable for students that want to gain additional skills the strengthening of cross-border cooperation of HEIs in the definition of quality flexible learning pathways for their learners, the increase of social responsibility of HEIs through the transparent descriptions of their offerings, the implementation of sustainable infrastructure for all European HEIs and for the EU to leverage in the enhancement of existing or the creation of new related services.

COMPASS will work to:

- *promote the concept of flexible lifelong learning pathways within HEI providers and learners through the use of innovative guidance instruments;*
- *produce policy suggestions for fomenting their implementation by higher education institutions;*
- *recommend standard information models for enabling Learning Opportunity (LO) providers to engage in the well-structured description of their offers (based on the MLO standard and extending it with learning outcomes and competence information)*
- *develop online services comprising a software component for LO description, to be made freely and publicly available to LO providers, and a free tool for lifelong learners to leverage LO information for building desired pathways for personal development;*
- *leverage the consortium span to policy makers, HEIs, industry as well as its ICT-sector orientation, to design and implementation-wide pilot tests that will boost awareness, institutional commitment and national impact.*

The produced models and technology can be exploited by national and European services (e.g. Ploteus), making an impact on the quantity and quality of LO information at both national and European level. For this purpose a technical recommendation for ingesting LO descriptions into Ploteus, will be produced.

APPENDIX 1 – SCHEMATIC VIEWS OF THE COMPASS METADATA SCHEMA

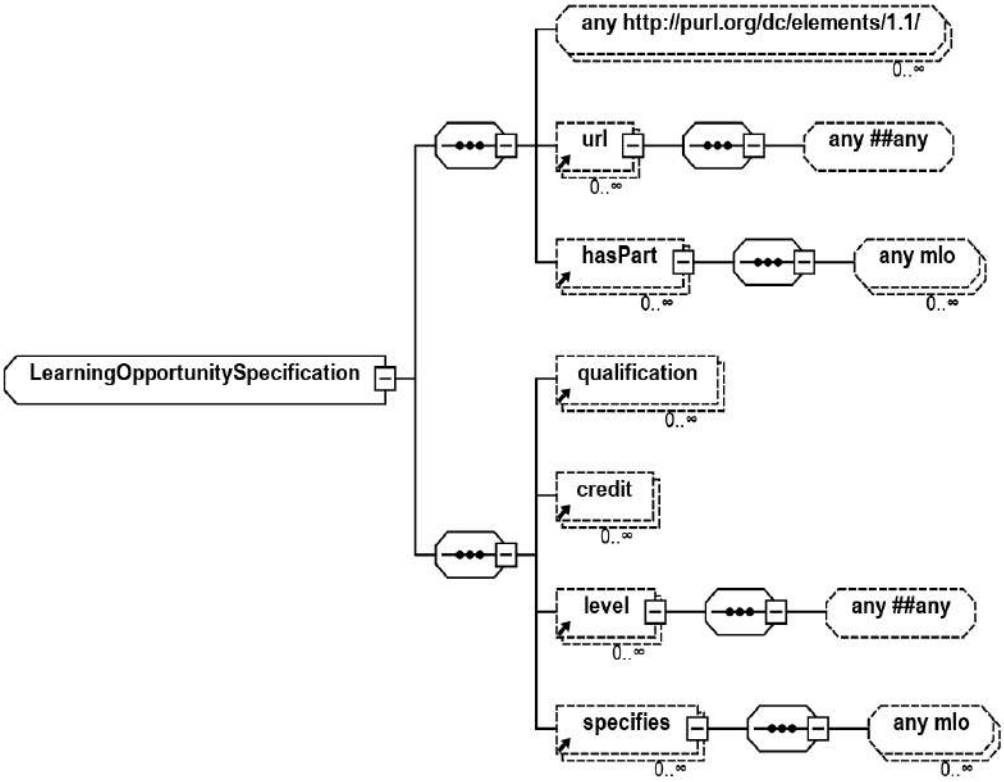

Figure 5: The LearningOpportunitySpecification element of the COMPASS metadata schema

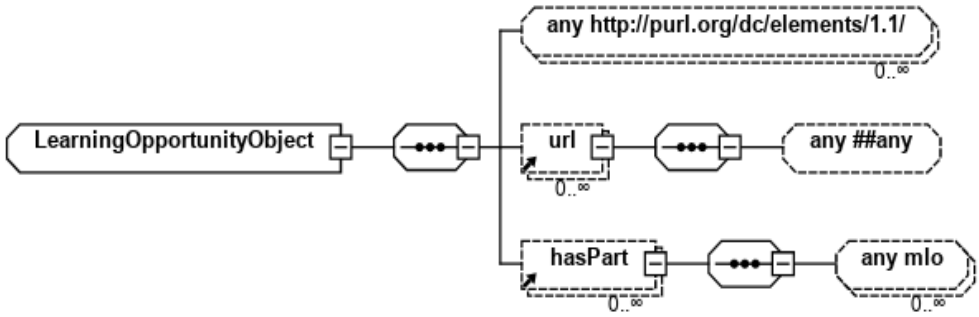

Figure 6: The LearningOpportunityObject element of the COMPASS metadata schema

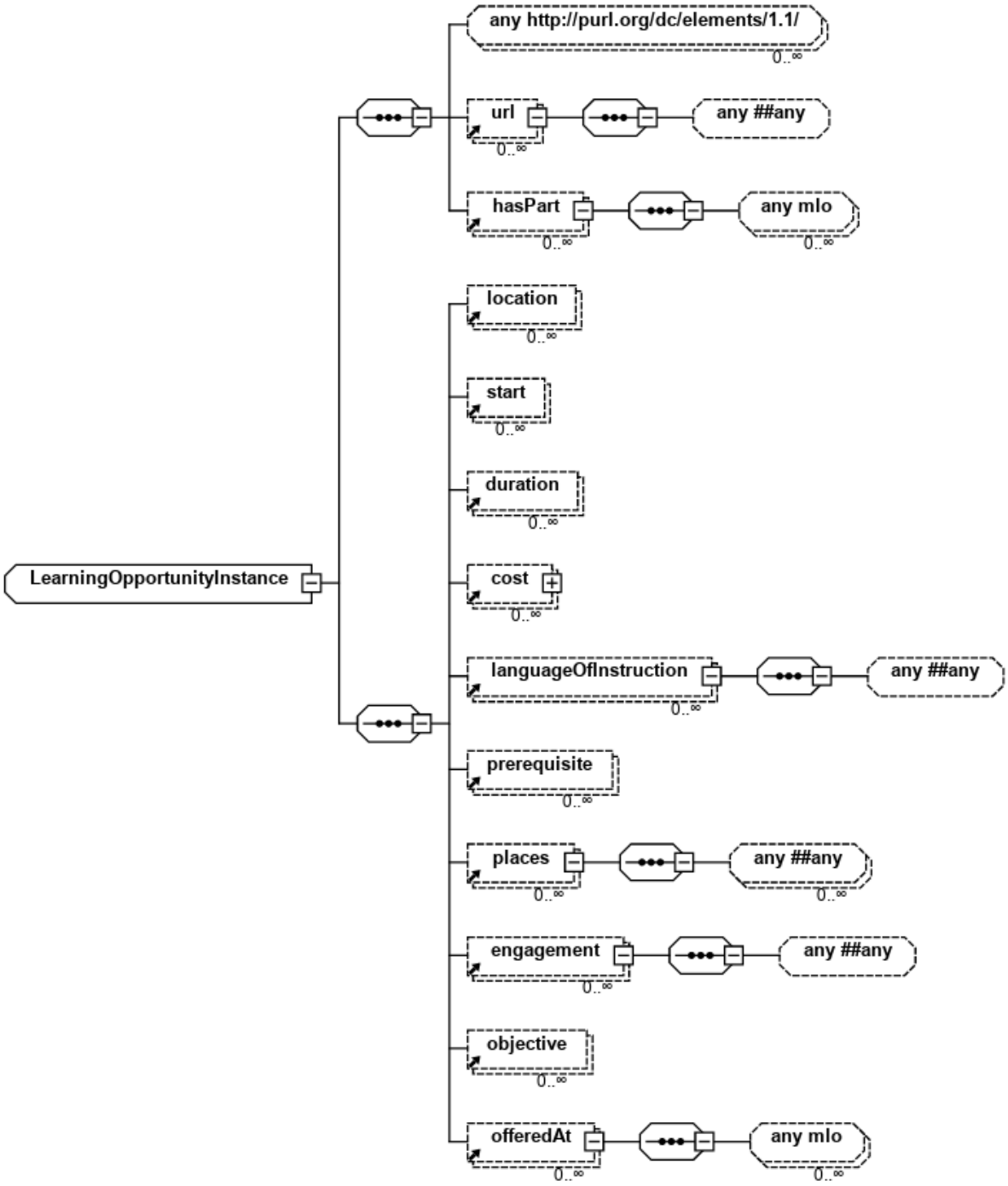

Figure 7: The LearningOpportunityInstance element of the COMPASS metadata schema

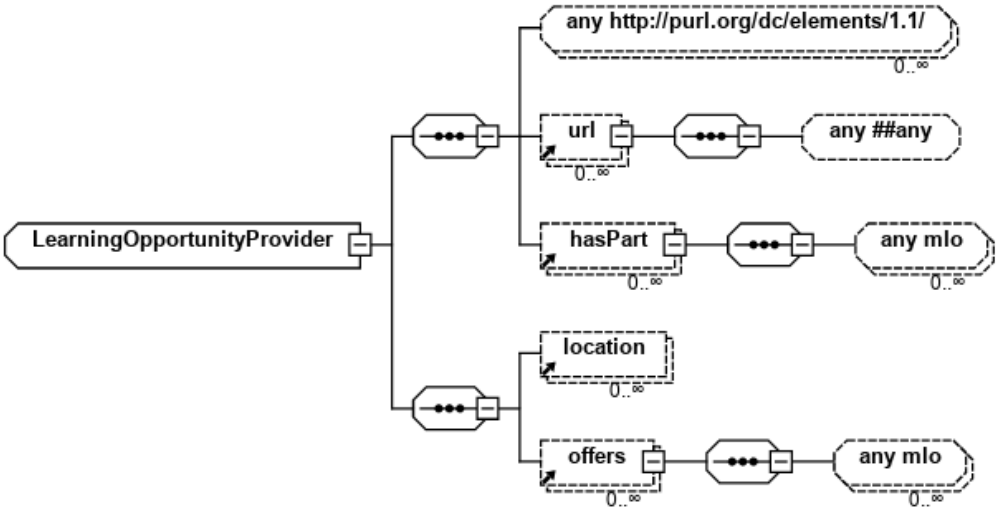

Figure 8: The LearningOpportunityProvider element of the COMPASS metadata schema

APPENDIX 2 – SAMPLE XML DOCUMENT OF A COMPASS LEARNING OPPORTUNITY DESCRIPTION

(a sample XML document, as created by the COMPASS online service shall appear here).