## SeLeNe : Self e-Learning Networks

# E-Learning Standards


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# SeLeNe Project

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# Executive summary

The scope of this document is to present an overview of existing standardization efforts for metadata associated with learning objects with a focus on their semantics and their capability to describe objects at different levels of granularity. Relying on a widely accepted definition of learning content available on corporate networks or the Internet, we detail the main features and structure of Learning Objects and present the most widely accepted metadata models proposed during the last years, as well as their interrelationships.

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# Abstract

Due to the increasing popularity of e-Learning applications, we are faced today with the need to establish standard ways for the definition, representation, transmission and reuse of learning content. In this report, we rely on a widely accepted definition of learning content being available on corporate networks or the Internet in order to detail the main features and structure of Learning Objects (LOs). In order to represent, transmit and reuse learning content over the Web, several models have been proposed during the last years focusing either on appropriate LO Metadata or Content Structure Modelling. These metadata models essentially define a means to describe learning materials in an interoperable way. In the sequel, we present the most significant standardization efforts concerning these complementary views of LOs as well as their respective interrelationships.


# 1. Introduction

Learning is an important mechanism for organizations of any kind to enhance the skills of their members. **E-Learning** is a distributed, student-oriented, personalized and non-linear/dynamic learning process [14] aiming to provide on-demand, task relevant educational material. The objective of e-Learning environments is to facilitate the accessibility and disposal of digital material -not necessarily primarily designed for educational purposes- to a wide spectrum of audience with diverse educational background and requirements: corporate staff, students, teachers or academics. A critical parameter of the e-Learning process that should be paid attention to is *time* (or lack of it), which requires not only a suitable content of the learning material (highly specified and not too general), but also a powerful mechanism for organizing and customizing such material according to user profiles and business demands. The interest of various user communities (e.g., educational, corporate, etc.) for e-Learning applications is continuously growing and many organizations across the world rely more and more on e-Learning implementations to support the learning processes they pursue.

E-Learning operations are based on the transmission of learning content across various computing environments and platforms; hence we have to define a structure unit that is suitable for this action. This “learning unit” is called **Learning Object** (LO) and its attributes as well as structure will be subsequently presented. In general, we designate as Learning Object any digital or physical object, which may function as a means for learning and is essentially what teachers and students -or other participants in the learning process- are sharing. However, the worldwide interest in implementing e-Learning operations raises a serious issue: there are many and different proposals for e-Learning prototyping that are resulting to huge interoperability problems. One feasible solution is the institution of some standard ways for the creation and transmission of e-Learning content (LOs) across the Web. To compensate for this need, there exist several standardization efforts concerning e-Learning modeling. We can distinguish the European consortium ARIADNE[1], the American IMS[2], ADL[3] and AICC[4] and the international efforts IEEE LTSC[5], ISO/IEC – JTC1/SC36[6], CEN/ISSS[7], DC[8] and W3C[9]. Till now, they have provided several standards with strong interrelationships. The purpose of this report is to expose these interrelationships and present what is available to teachers, students and academics to find and (re)use digital educational material, as well as identify what is also needed by metadata standards to fully support e-Learning applications.

The organization of this report is as follows. Section 2 provides a working definition of Learning Objects (LOs) and identifies the different granularity levels into which one LO could be decomposed. Furthermore, it refers to representational aspects of LOs, such as their main descriptive attributes and conceptual representation levels. Section 3 presents the main standardization efforts and their interrelationships, with the focus on standards for Learning Objects' metadata and content structure modeling. Section 4 concludes this report by identifying aspects that stand in need of attention in the new, dynamic e-Learning environments.

1 http://www.ariadne-eu.org/
2 http://www.imsproject.org/
3 http://www.adlnet.org/
4 http://www.aicc.org/
5 http://ltsc.ieee.org/
6 http://jtc1sc36.org/
7 http://www.cenorm.be/isss/
8 http://dublincore.org/
9 http://www.w3.org/

# 2. Learning Objects

There are various proposals for defining a Learning Object (LO). Some of these refer only to digital objects, but almost all proposals include every digital or physical object with learning content. One of the simplest views of learning objects is simply as re-usable components of courses. These components can vary in size (e.g., a diagram, a question, an exam paper, a lecture), but are generally thought of as being smaller than an entire course. Few people would argue with this definition, but is general enough to be of use. Thus, more formal definitions have been proposed. More precisely, according to the Learning Technology Standards Committee[10] (LTSC) of the IEEE:

*A Learning Object can be any entity, digital or not, that can be used or referenced in technology-supported learning.*

The Learning Objects Network Inc[11]. (LON) uses an equally broad definition:

*Learning objects are small stand-alone "chunks" of information designed to be easily reused and repackaged to meet the needs of different audiences. They typically are designed to achieve a certain narrow learning objective and may contain an assessment to determine success against that objective. Learning objects may reflect varying degrees of granularity ranging from as large as a chapter in a book, a case study, or an interactive courseware topic, to smaller items such as a single pedagogical concept (teaching the boiling point of water, for example).*

This ubiquity of learning objects is not a bad thing in itself -it is true that anything that has existed can be put to some educational use, so maybe we should allow the definition of learning object to be as broad as this. In general, we can distinguish LOs into two categories:

1) **Physical LOs**, which are non-digital entities, like a simple text or a workbook. These objects must have a digital surrogate for their “Web” representation, e.g., a book that is not available online as a whole could have a URL reference in a Web page, which is the digital surrogate of the book.

2) **Online LOs**, which are related straightly with web environments. For example, an online .gif image, a Web page or a Java applet recommending a Web browser could be online LOs.

The learning objects described by the metadata in a Self e-Learning Network are to be those available on the Web (online LOs), so it is proposed that we use the term “Learning Object” to mean “Learning Object available on the Web”. One of the key

[10] http://ltsc.ieee.org
[11] http://www.learningobjectsnetwork.com/Concepts.htm

advantages of web-based resources as educational tools is that they can be used simultaneously by many users, unlike traditional resources, such as textbooks and worksheets, where each learner needs a separate copy. Maybe a working definition (which borrows from Simon and Quemada (2002)'s definition of "educational material") for use in SeLeNe could be something like:

*Learning objects are electronic, sharable chunks of reusable learning content, available on the Web.*

This definition includes both static and dynamic web-based objects at all levels of granularity, but excludes physical objects, such as textbooks and CD-ROM's, which are not sharable and cannot be stored in the kind of distributed learning-object repositories envisaged in the SeLeNe project. Next section specifically refers to the granularity levels of LOs.

## 2.1 Granularity of Learning Objects

We can observe that in real life there is a wide spectrum of learning content w.r.t. its size and scope. Learning content could range from a single slide to a PHD certificate. Also, learning content can be used for different goals, e.g., as a lesson, a course or a simple notation. These facts impose a flexible representation of a LO with respect to the size and scope of each learning content. This has led to the distinction of *granularity levels* of a LO. The general granularity level hierarchy of LOs is shown in Figure 1, where we present an example of the second-year course CS252 (Object-Oriented Programming) of the Computer Science Department (CSD) at the University of Crete.

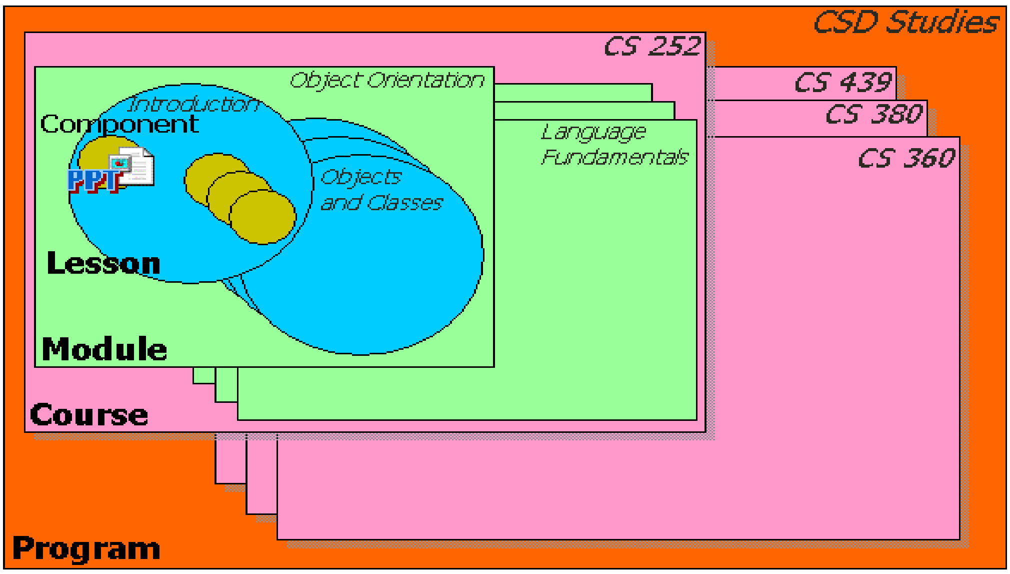



***Figure 1: Learning Object's Granularity (CS252 Example)***

The first and simplest level (lowest level) is the ***information object*** or ***component*** and represents every object that might be used in the learning process, like a photograph, a 3D image, a simple text or a video clip. For example, a single component can be a video clip from a speech. This video clip becomes a LO when a lesson is added to it. As we can figure, many different LOs can be created from one single component. Thereby, for instance, from the video clip above, one could create lessons in history, media studies and many other subjects. In the CS252 example, a simple .ppt slide is a component. We can observe that LOs of this granularity level cannot contain other LOs. These are considered to be the *atomic* LOs. The LOs belonging to the remaining granularity levels can contain other LOs and are considered to be *complex* LOs.

More specifically, the second level is the ***Lesson***. A lesson is a grouping of components with relative theme (aka the lesson's theme) and its duration is typically less than 90 minutes. In the CS252 example, the slides of the introduction in object-oriented programming constitute the components of the lesson "Introduction" of CS252. The third level is the ***Module***, with a module constituting a LO of less than 10 hours of learning duration. Modules are longer learning experiences or groupings of lessons. In the CS252 example, the grouping of the lessons "Introduction", "Objects and Classes" and other relative lessons with initiative information in OOP comprises the module "Object Orientation" of CS252. If lessons are longer than 10 hours or if they consist of more than one module, they are considered to be a ***Course*** (fourth level). That is, a course is a grouping of a large number of lessons or a grouping of modules. In the CS252 example, it is obvious that the group of all lessons or the group of all modules of CS252 represent the course itself. Lastly, the ***Program*** represents the fifth and higher level. A program is a group of courses that lead towards a certificate or a diploma. In the example of Figure 1, we can observe that the grouping of all courses at the Computer Science Department constitutes the "CSD Studies" program leading to the CSD Graduate Diploma.

## 2.2 Representation of a Learning Object

LOs are characterized by distinguished relationships among them or other entities applied to them. An approach to the conceptual representation of LOs is shown in Figure 2, which presents a simplified model for describing LOs using attributes with information about their content as well as their pedagogical value.

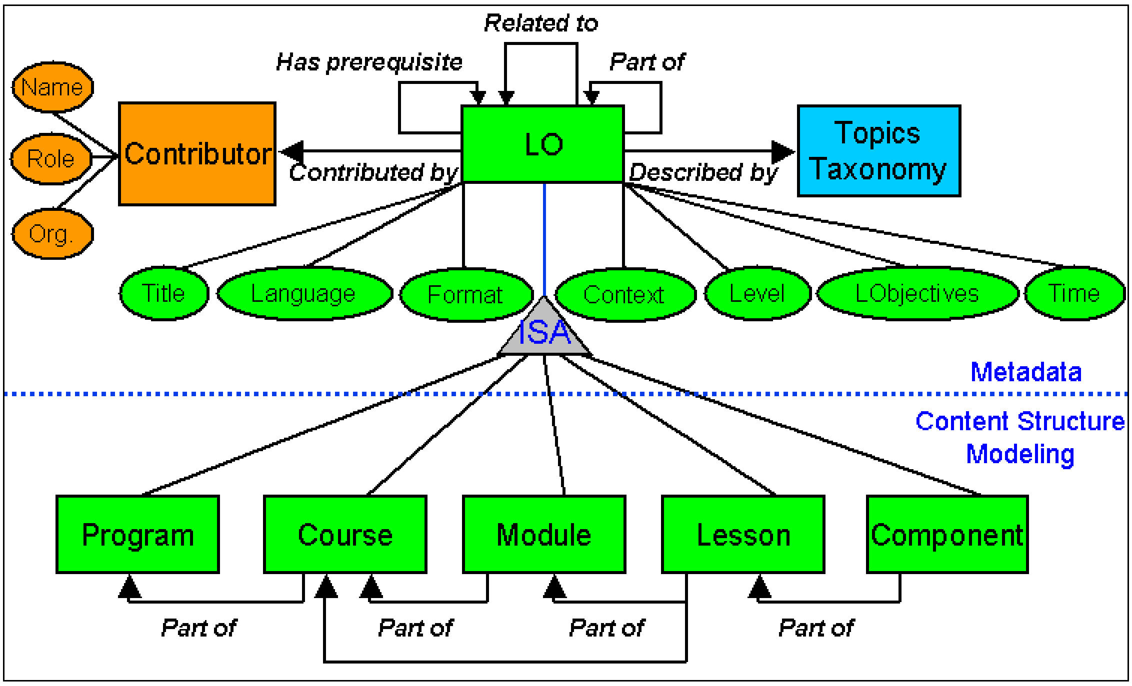



***Figure 2: Conceptual Representation of LOs***

### 2.2.1 Main descriptive attributes of Learning Objects

As we can observe in Figure 2, there are five kinds of attributes used to describe a LO:

1) *Contributor of a LO:* a contributor of a LO is primarily a person or an organization. There is a standard way of referencing this relation by DC elements (*DC.contibutor, DC.creator, DC.publisher*). All other standards just supplement inconsequent information about the contributor. For example, as we will examine in Section 3.2.1, IEEE LOM expands the set of the contributor roles to include more specific role definitions.

2) *Subject Registration of a LO:* the subject of a LO can refer to a term in a Topics Taxonomy. This attribute has not yet been stabilized to a specific form, like the ACM Computing Classification System[12] and every standard uses its own taxonomy function. For example, DC has a specified element called *subject*, while IEEE LOM provides a whole *classification* category.

3) *Relationships between LOs:* every LO can be related with another LO by multiple kinds of relations, such as a *part of* relationship capturing learning material composition trees, a *prerequisite* relation capturing learning dependency graphs or a *related to* relation representing correlation

[12] http://www.acm.org/class/1998/homepage.html

networks. This is obvious with the observation that a whole learning process (like a course) and its sub-components (like lessons, videos or presentations) or other relative processes (like a prerequisite course of a course) could be LOs.

4) *Subsumption (ISA) relations between a LO and its granularity* levels: when learning material does not appear in isolation, *structure* is needed to encompass a set of learning objects in an educational unit. Every existing LO could belong in one of the general granularity levels, namely *Component, Lesson, Module, Course* and *Program*. These levels should be interconnected with *part of* relations in order to build a complete educational unit comprising these levels. Thereby, a *Component* is a part of a *Lesson*; a *Lesson* is a part of a *Module* or *Course*; a *Module* is a part of a *Course* and a *Course* is a part of a *Program*.

5) *General descriptive attributes*: we can also identify attributes describing the *content* (e.g., *title*, *language*, *format*) and *pedagogical value* (e.g., *context*, *level*, *learning objectives*, *time*) of a LO. As learning or educational objectives, we characterize the teaching-related objectives instructors aim to achieve by using the provided educational material in an educational environment [13]. Educational *context* and *level* refer respectively to the typical target audience context and its educational level (e.g., undergraduate studies, second year), while *time* refers to the typical learning time required to achieve the educational objectives.

The set of these attributes constitute the minimal set of attributes needed to efficiently describe a Learning Object in order to facilitate its easy retrieval.

### 2.2.2 Learning Object's conceptual representation layers

The conceptual representation of Learning Objects can take place in two layers. These layers are presented in Figure 2 and are distinguished by the blue dotted line. More specifically, we can identify:

1) The ***Metadata*** (upper) layer: This level comprises the most significant descriptive properties of LOs of various granularity levels. That is, the LO attributes (e.g., title, language, format, context, level, learning objectives and typical learning time) and the LO relationships (e.g., "Related to", "Has prerequisite", "Part OF", "Described by" and "Contributed by").

2) The ***Content Structure Modeling*** (lower) layer: This level comprises the composition structure of LOs at various granularity levels in order to exchange and share LOs between platforms and applications.

There is a tight relation between Metadata and Content Structure Modeling. In Content Structure Modeling, Metadata are used for describing the LOs being structured. On the other hand, Metadata standards rely on the representation of the composition of LOs, as provided by the various Content Structure Models. A significant statement for Metadata and Content Structure Modeling is that both can define LO *prerequisites*. We will examine how prerequisites are defined in these layers in Section 3.

# 3. E–Learning standards

E-Learning metadata standards constitute formal specifications of the descriptive terms used to semantically annotate educational material of all kinds. In this section, we will present the main information concepts involved in e-Learning standards. More specifically, an e-Learning standard *may be*:

1) ***Formal*** or "***de jure***", when a specification's status is designed and certified by an accredited body, like IEEE or ISO
2) "***de facto***", when the standard is adopted and used by the majority of users.

An e-Learning standard *is needed for*:

1) ***Durability***. There is no need for modification as versions of system software change
2) ***Interoperability***. We can have interoperability across a wide variety of hardware, Operating Systems, Web browsers and Learning Management Systems. This is the most significant advantage of the presence of an e-Learning standard
3) ***Accessibility***. The operations of indexing and tracking can be handled on our demands
4) ***Reusability***. There is possible modification and use by many different development tools.

An e-Learning standard *addresses*:

1) ***Learning Object structure***, with the use of *metadata*
2) ***Content sharing/packaging***, using interoperable *Content Structure Models*.

In the next two subsections, we are going to explore the characteristics of e-Learning standards referring both to the structure and the Content Structure Modelling of Learning Objects.

## 3.1 Main e-Learning standards

From the variety of the e-Learning standards proposed from time to time, we can distinguish the six, widely accepted standards listed below:

1) **IMS** (Instructional Management System)
2) **ARIADNE** (Alliance of Remote Instructional Authoring & Distribution Network for Europe)
3) **DC** (Dublin Core)
4) **IEEE/LOM** (Institute of Electrical and Electronic Engineers/Learning Object Metadata)
5) **ADL/SCORM** (Advanced Distributed Learning/Sharable Courseware Object Reference Model)
6) **AICC** (Aviation Industry CBT Committee), where CBT stands for Computer Based Training

Their main focus and interrelations are graphically depicted in Figure 3, which represents an IMS CP-centred overview of the main e-Learning standards.

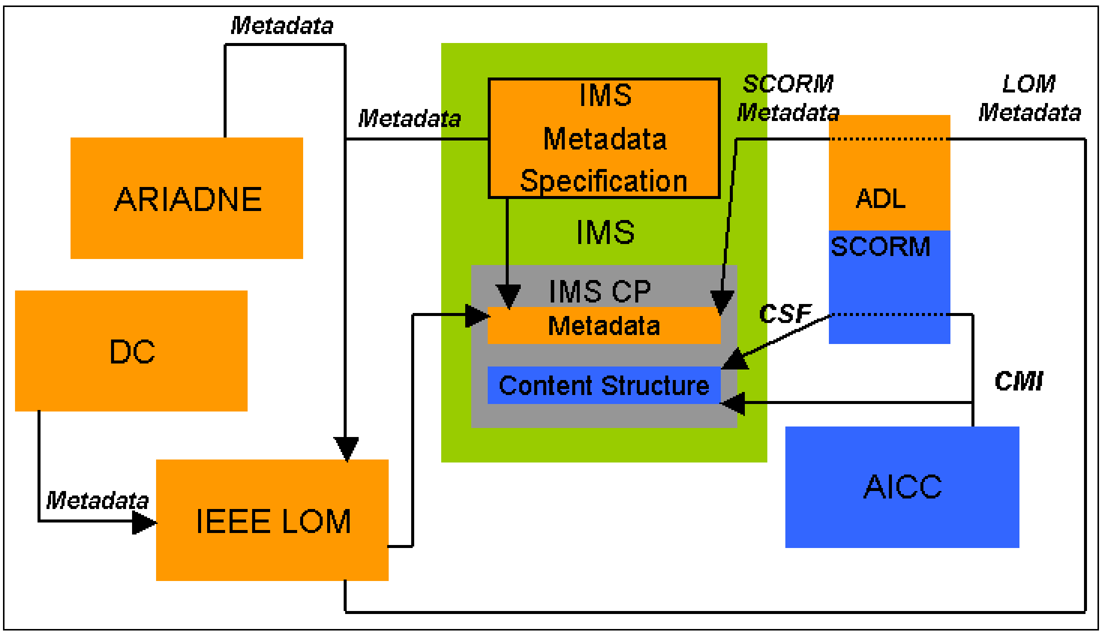



***Figure 3: Interrelationships of e-Learning standards***

The orange boxes represent the standards for *Metadata* specification (namely, ARIADNE, DC, IEEE LOM, IMS Metadata Specification, ADL) and the blue boxes the standards for *Content Structure Modelling* (namely, SCORM, AICC). We can observe that IMS and ADL/SCORM handle both Metadata specification and Content Structure Modelling. More precisely:

- The arrows labelled *Metadata* connecting IMS, ARIADNE and IEEE LOM represent the joint proposal of the first two standards that led to the creation of the IEEE LOM standard
- The arrow labelled *Metadata* from DC to IEEE LOM shows the contribution of DC on some metadata elements of IEEE LOM
- The arrow named *CMI* represents the AICC CMI (Computer Managed Instruction) Model for content structuring
- The arrow named *CSF* represents the SCORM CSF (Content Structure Format) Model for content structuring
- The dotted line in the lower (blue) part of ADL/SCORM indicates that SCORM CSF is derived from AICC CMI
- The dotted line in the upper (orange) part of ADL/SCORM shows the mapping of IEEE LOM Metadata to SCORM Metadata
- The grey box labelled *IMS CP* in IMS represents the IMS CP (Content Packaging) specification, which comprises a part for Metadata and a part for *Content Structure* organizations
- The arrows pointing at the *Metadata* part of IMS CP indicate the standards that can be used there, like IEEE LOM, IMS Metadata, SCORM Metadata or others
- The arrows pointing at the *Content Structure* part of IMS CP show the standards that can be used there, like SCORM CSF, AICC CMI or others. Note that, IMS CP can also use the *Table Of Contents (TOC)* Model for content structuring.

Next subsections provide a more in-depth description by means of example metadata records of the e-Learning standards mentioned above w.r.t. their main focus.

## 3.2 Standards for Learning Objects Metadata

### 3.2.1 IEEE LOM

As already mentioned, IEEE LOM [4, 5] has been created from the joint proposal of IMS and ARIADNE to IEEE. It cooperates with DC by using DC elements for the base definition of some LOM elements. For example, the *identifier*, *title*, *language* and *description* elements in LOM are based on the DC elements *DC.identifier*, *DC.title*, *DC.language* and *DC.description* respectively. This standard:

- Specifies the syntax and semantics of LO Metadata using XML DTDs
- Provides the attributes required to adequately describe a LO (e.g., element name, data type, definition, vocabulary, field length)
- Is focused on a minimal set of attributes for the management, location and evaluation of LOs
- Constitutes the most comprehensive metadata standard till now and forms the basis of almost all existing implementations of metadata specifications for learning objects.

The *Royal Institute of Technology*[13] in Stockholm provides the RDF/S (Schema) [3, 10] bindings [11] for the last version of LOM that has been released, namely LOM Final Draft v1.0 [4].

More specifically, IEEE LOM specifies nine categories for over 70 metadata elements associated with LOs. These categories are shown in Table 1. All nine categories are *optional*; hence a LOM instance with no values for any of the elements is still a qualified metadata record for LOM standard. In this sense, most of the existing implementations of LO metadata conform to IEEE LOM; they generally define some of the LOM elements to be mandatory and extend this set of elements with their own "custom" elements.

[13] http://www.kth.se/eng/

| | |
|---|---|
| ***General*** | Groups the general information describing a LO as a whole |
| ***Life Cycle*** | Describes the history and current state of a LO and those who have affected the LO during its evolution |
| ***Meta-Metadata*** | Describes the specific information about the metadata record itself (e.g., who created this record, how and when) |
| ***Technical*** | Describes the technical requirements and characteristics of a LO |
| ***Educational*** | Describes the key educational or pedagogic characteristics of a LO |
| ***Rights*** | Describes the intellectual property rights and conditions of use for a LO |
| ***Relation*** | Defines the relationship between a LO and other targeted LOs, if any |
| ***Annotation*** | Provides comments on the educational use of a LO, who created this annotation and when |
| ***Classification*** | Describes where a LO is placed within a particular classification system |

***Table 1: IEEE LOM Categories***

LOM standard respects the general granularity hierarchy of LOs depicted in Figure 2. In particular, it has established six granularity levels, which are shown in Table 2:

| | |
|---|---|
| ***First level (higher)*** | ***Curriculum***, like Program |
| ***Second level*** | ***Course*** |
| ***Third level*** | ***Unit*** (higher level Module) |
| ***Fourth level*** | ***Topic*** (lower level Module) |
| ***Fifth level*** | ***Lesson*** |
| ***Sixth level (lower)*** | ***Fragment***, like Component |

***Table 2: IEEE LOM Granularity Levels***

#### 3.2.1.1 IEEE LOM CS252 example

In order to exemplify the use of IEEE LOM for annotating learning material, we present a metadata record conforming to the IEEE LOM Final Draft v1.0 [2]. This metadata record refers to the example course CS252 offered by the Computer Science Department studies program of the University of Crete. Instead of an XML document, we presented textually the values of the elements ordered by the category they belong to and the index that LOM Final Draft v1.0 assigns to them:

1.1.1. *General.Identifier.Catalog* "URI"

1.1.2. *General.Identifier.Entry* "http://www.csd.uoc.gr/~hy252"

| | | |
|---|---|---|
| 1.2. | *General.Title* | ("en","CS252: Object Oriented Programming") |
| 1.3. | *General.Language* | "en", "gr" |
| 1.4. | *General.Description* | ("en", "This course analyzes the main principles and characteristics of Object Oriented Programming"), ("gr", "Το μάθημα αυτό αναλύει τις βασικές αρχές και ιδιότητες του Οντοκεντρικού Προγραμματισμού") |
| 1.5. | *General.Keyword* | ("en", "Object Oriented Programming"), ("gr","Οντοκεντρικός Προγραμματισμός") |
| 1.6. | *General.Coverage* | ("en", "University of Crete, Spring 2002, Greece"), ("gr", "Πανεπιστήμιο Κρήτης, Άνοιξη 2002, Ελλάδα") |
| 1.7. | *General.Structure* | ("LOM v1.0", "linear") |
| 1.8. | *General.Aggregation Level* | ("LOM v1.0", "3") |

The Aggregation Level element value depends on the granularity level of the LO. Here, the LO CS252 is a course, so the value is 3 (Level 3).

| | | |
|---|---|---|
| 2.2. | *Life Cycle.Status* | ("LOM v1.0", "final") |
| 2.3.1. | *Life Cycle.Contribute.Role* | ("LOM v1.0", "author") |
| 2.3.2. | *Life Cycle.Contribute.Entity* | vCard of Dr. Vassilis Christophides |
| 2.3.3. | *Life Cycle.Contribute.Date* | "2002-02-10" |

| | | |
|---|---|---|
| 3.2.1. | *Meta-Metadata.Contribute.Role* | ("LOM v1.0", "creator") |
| 3.2.2. | *Meta-Metadata.Contribute.Entity* | vCard of Miltos Stratakis |
| 3.2.3. | *Meta-Metadata.Contribute.Date* | "2002-11-18" |
| 3.3. | *Meta-Metadata.Metadata Schema* | "LOM v1.0" |

Caution: LOM v1.0 means the LOM Final Draft v1.0 Schema.

| | | |
|---|---|---|
| 3.4. | *Meta-Metadata.Language* | "en" |

| | | |
|---|---|---|
| 4.1. | *Technical.Format* | "text/html", "application/pdf" |
| 4.3. | *Technical.Location* | "http://www.csd.uoc.gr/~hy252" |
| 4.4.1.1. | *Technical.Requirement.OrComposite.Type* | ("LOM v1.0", "browser") |

4.4.1.2. *Technical.Requirement.OrComposite.Name*
("LOM v1.0", "netscape communicator")
4.4.1.1. *Technical.Requirement.OrComposite.Type*
("LOM v1.0", "browser")
4.4.1.2. *Technical.Requirement.OrComposite.Name*
("LOM v1.0", "ms-internet explorer")

5.1. *Educational.Interactivity Type* ("LOM v1.0", "expositive")
5.2. *Educational.Learning Resource Type* ("LOM v1.0", "index")
5.3. *Educational.Interactivity Level* ("LOM v1.0", "3")

Interactivity Level 3 means that this LO has medium interactivity with the learner.

5.4. *Educational.Semantic Density* ("LOM v1.0", "4")

Semantic Density 4 means that this LO has high semantic density, since it consists of refined pdf documents.

5.5. *Educational.Intended End User Role* ("LOM v1.0", "learner")
5.6. *Educational.Context* ("LOM v1.0", "higher education")
5.7. *Educational.Typical Age Range*
("en", "suitable for university students")
5.8. *Educational.Difficulty* ("LOM v1.0", "3")

Difficulty 3 means that CS252 has medium difficulty for the typical intended target audience.

5.9. *Educational.Typical Learning Time* "P4M" (that is 4 months)
5.11. *Educational.Language* "en", "gr"

6.1. *Rights.Cost* ("LOM v1.0", "no")
6.2. *Rights.Copyright and Other Restrictions* ("LOM v1.0", "no")

7.1. *Relation.Kind* ("LOM v1.0", "haspart")
7.2.1.1. *Relation.Resource.Identifier.Catalog* "URI"
7.2.1.2. *Relation.Resource.Identifier.Entry*
"http://www.csd.uoc.gr/lectures/CS252Basics.pdf"
7.2.2. *Relation.Resourse.Description*

("en", "Java Programming Basics is an initiative lesson of CS252 course"),

("gr", "Τα βασικά χαρακτηριστικά του προγραμματισμού σε Java είναι εισαγωγικό μάθημα στον Οντοκεντρικό Προγραμματισμό")

7.1. *Relation.Kind* ("LOM v1.0", "requires")

7.2.1.1. *Relation.Resource.Identifier.Catalog* "URI"

7.2.1.2. *Relation.Resource.Identifier.Entry* "http://www.csd.uoc.gr/hy150"

7.2.2. *Relation.Resourse.Description*

("en", "CS150 is a prerequisite course of CS252"),

("gr", "Το HY150 είναι προαπαιτούμενο του Οντοκεντρικού Προγραμματισμού")

In the previous Relation category instance we defined a *prerequisite* of CS252. This is the standard way that IEEE LOM defines LO *prerequisites*.

7.1. *Relation.Kind* ...

7.2.1.1. *Relation.Resource.Identifier.Catalog* ...

7.2.1.2. *Relation.Resource.Identifier.Entry* ...

7.1. *Relation.Kind* ...

7.2.1.1. *Relation.Resource.Identifier.Catalog* ...

7.2.1.2. *Relation.Resource.Identifier.Entry* ...

In this metadata record we have multiple *Relation* category instances for the definition of the multiple relations of CS252 with other LOs. The kinds of relations that IEEE LOM Final Draft v1.0 provides are shown in Table 3.

| ***Relation Kind*** | ***Value space in IEEE LOM*** |
|---|---|
| Is Part Of | Ispartof |
| Has Part | Haspart |
| Is Version Of | Isversionof |
| Has Version | Hasversion |
| Is Format Of | Isformatof |
| Has Format | Hasformat |
| References | References |
| Is Referenced By | Isreferencedby |
| Is Based On | Isbasedon |
| Is Basis For | Isbasisfor |
| Requires | Requires |
| Is Required By | Isrequiredby |

***Table 3: IEEE LOM Relation Kinds***

Let us now see how CS252 can be described using terms from the *ACM Computing Classification System*[14]. The above IEEE LOM metadata record continues as follows:

9.1. *Classification.Purpose* ("LOM v1.0", "educational level")
9.2.1. *Classification.Taxon Path.Source* ("en", "ACM")
9.2.2.1. *Classification.Taxon Path.Taxon.Id* "D.1.5"
9.2.2.2. *Classification.Taxon Path.Taxon.Entry*
("en","Object-oriented Programming")
9.3. *Classification.Description*
("en", "A university second-year course introducing OOP")
9.4. *Classification.Keyword* ("en", "OOP courses")

This *Classification* category instance places the subject of CS252 in a particular term within *ACM* taxonomy with ID *"D.1.5"* and label *"Object-oriented Programming"*.

#### 3.2.1.2 IEEE LOM Metadata: What do they actually provide?

Figure 4 shows the undergraduate courses of CSD and their *prerequisite* interrelations, if any. The course to which an arrow ends is a *prerequisite* of the course from which this arrow starts. An IEEE LOM metadata record of CS252 can define the

[14] http://www.acm.org/class/1998/

*prerequisite courses* of this course (with Relation.Kind = Requires) and the *courses that CS252 is a prerequisite course* (with Relation.Kind = Is Required By). In Figure 4, the area this metadata record applies is highlighted with a red-coloured, dashed rectangle, where:

- CS150 designates the course "Programming in C"
- CS359 designates the course: "Web Programming".

As we can observe, if we ignore the courses that do not have or are prerequisites for other courses, then Figure 4 represents a *Directed Acyclic Graph (DAG)* of the *prerequisite* relations of the courses at the CSD Undergraduate Program.

Practically, we rarely say, "CS252 course requires the "*Variables and Functions Definitions*" lesson of the CS150 course". We usually say, "CS252 course requires CS150 course". Therefore, we can consider that the *prerequisite* relations are usually applied to LOs of the same granularity level. However, in the case of prerequisites between modules and lessons, we can have statements, such as "The "*Language Fundamentals*" module requires the "*Designing Classes*" lesson" or "The "*Searching and Sorting*" lesson requires the "*Language Fundamentals*" module". Hence, the above consideration is incomplete, as long as there are prerequisite relations between LOs of two different granularity levels, *Module* and *Lesson*. In fact, if we take a closer look at *Module* and *Lesson* granularity levels, we will find out that these two levels are *approximate*. Actually, LOs of both levels could be direct divisions of a *Course*. Therefore, we can extend our consideration to this: The *prerequisite* relations are usually applied to LOs of the same or approximate (case *Module* and *Lesson*) granularity level. With our new extended consideration and the observation made in Figure 4, we can assert that with the use of IEEE LOM metadata we can provide a *DAG* of the *prerequisite* relations between LOs of the same or approximate granularity level.

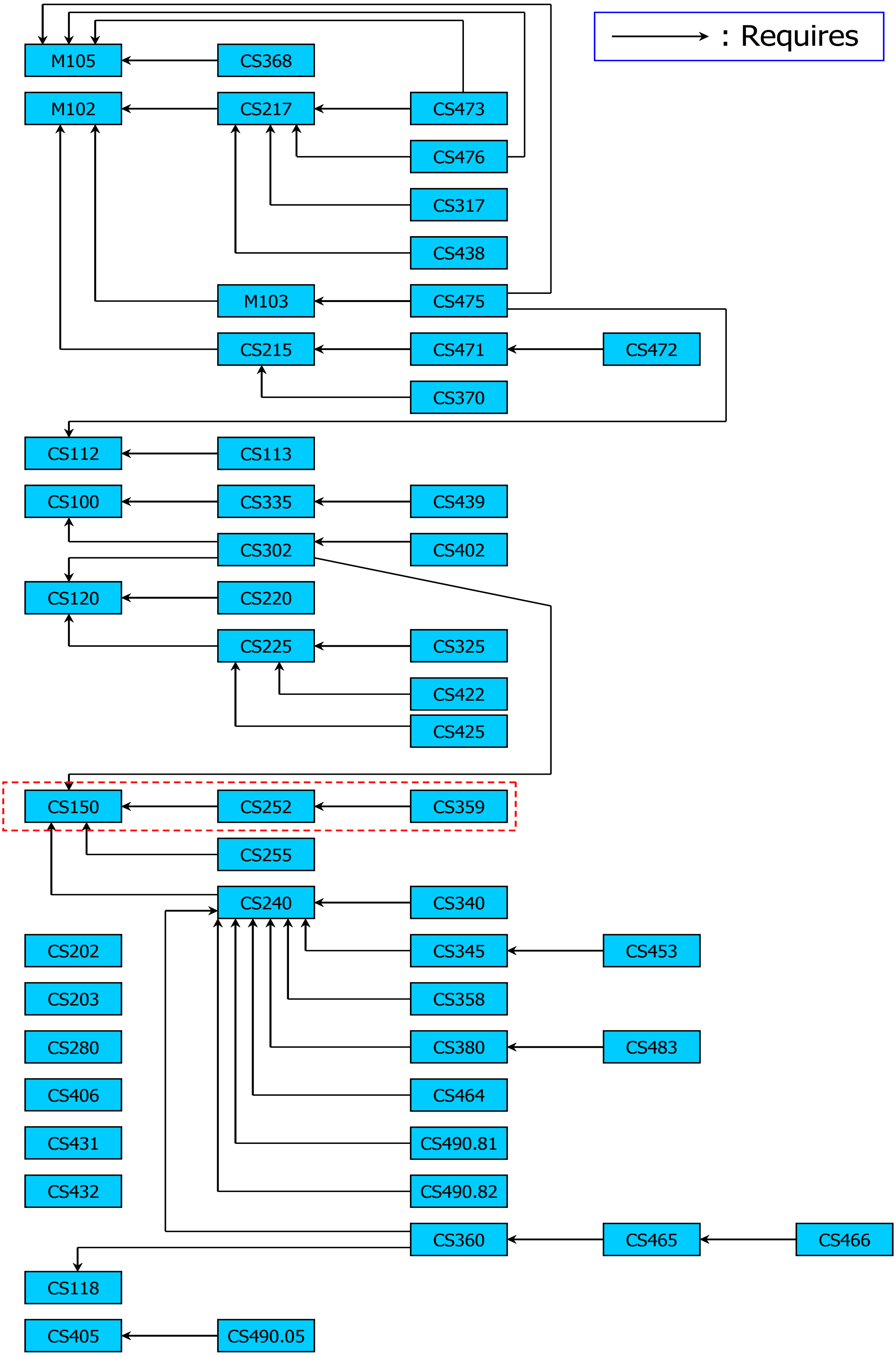



*Figure 4: The prerequisites of CSD Undergraduate courses*

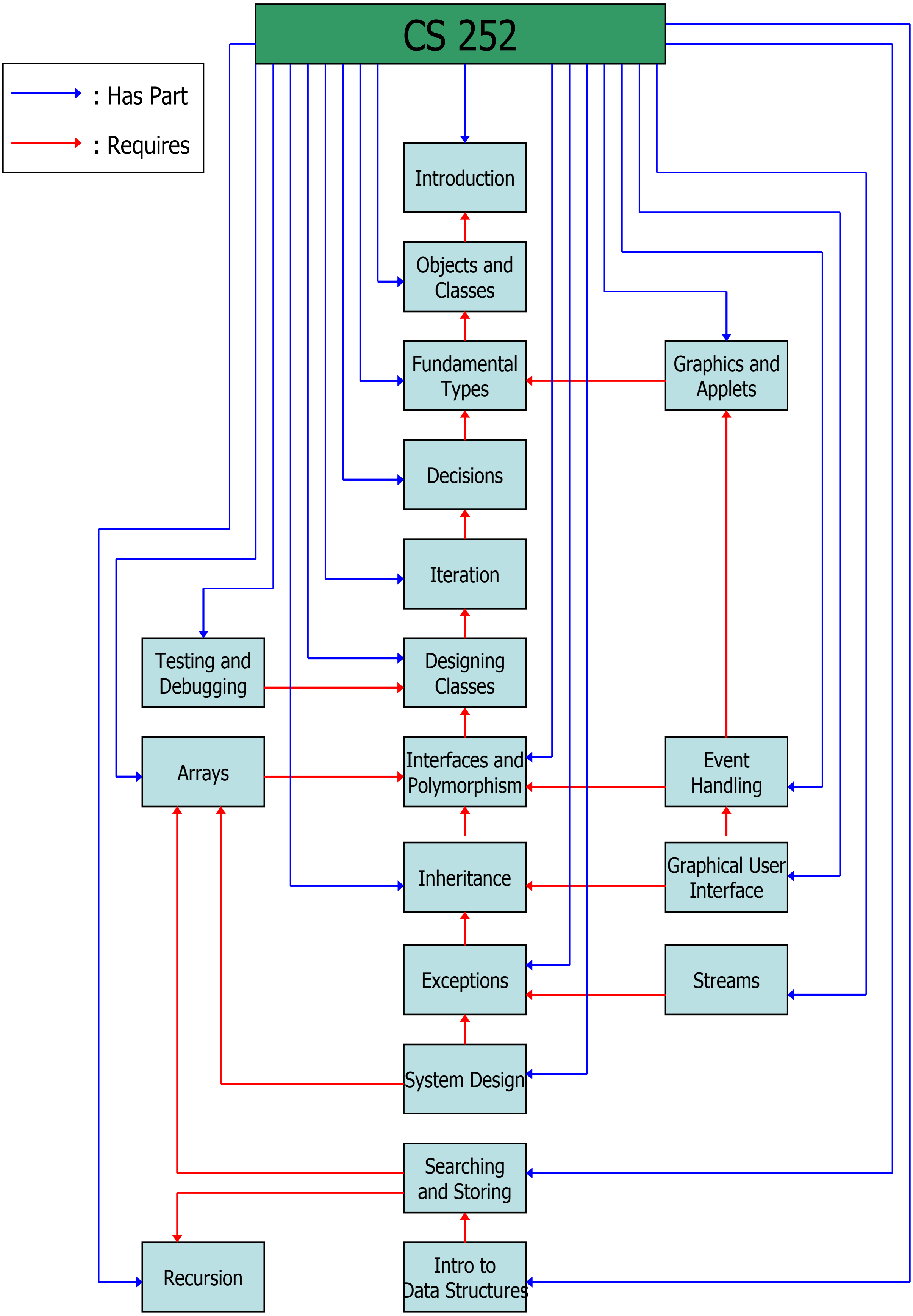



***Figure 5: CS252 lessons and their dependencies***

Figure 5 presents the structure of CS252 through its lessons using IEEE LOM Metadata Relation Kinds. The blue arrows represent the IEEE LOM "*Has Part*" relations between the course and the lessons this course comprises and the red arrows represent the IEEE LOM "*Requires*" relations (aka the *dependencies*) between these lessons. As we can observe, the blue arrows yield a *tree* representation of CS252. Therefore, a *complex* LO (e.g., a course) containing LOs of lower granularity levels (e.g., lessons) can be represented by a *tree* using IEEE LOM Metadata. Also, keeping in mind the conclusions made from Figure 4, we can easily figure out that the red arrows give us a DAG representation of the *prerequisite* relations between CS252 lessons. This new DAG is considered to be a lower level DAG than the one in Figure 4, as it contains LOs of lower granularity level (the granularity level *Lesson* is lower than the granularity level *Course*).

Generalizing the above observations, with the use of IEEE LOM Metadata we can create a tree representation for every complex LO and DAGs of the prerequisite relations between:

- LOs of the same (or approximately the same in case of *Module* and *Lesson*) granularity level, which are contained in a complex LO
- LOs of the same (or approximately the same in case of *Module* and *Lesson*) granularity level that the complex LO belongs.

Figure 6 exhibits a graphical representation of two complex LOs that belong to the granularity level *Program*. The blue and the red arrows stand for the "*Has Part*" and "*Requires*" relations of IEEE LOM Metadata respectively. Examining Figure 6, we can observe that the blue arrows create a *tree* representation for each of the two programs. These two *trees* are separated by black-coloured, dashed rectangles. Also, we can observe that the red arrows in Figure 6 create DAGs of five different levels:

1) The *Program* level DAG: This DAG contains the *prerequisite* relations between *Programs*. In Figure 6, the one DAG of this level is represented by an aqua-colored, dashed rectangle.
2) The *Course* level DAG: This DAG contains the *prerequisite* relations between courses of the same program. In Figure 6, the two *DAGs* of this level are represented by sky blue-colored, dashed rectangles.
3) The *Module/Lesson* level DAG: This *DAG* contains the *prerequisite* relations between the lessons, if any, and the modules, if any, of the same course. The lessons in this DAG are not part of the modules. In Figure 6, the five DAGs of this level are represented by green-colored, dashed rectangles.

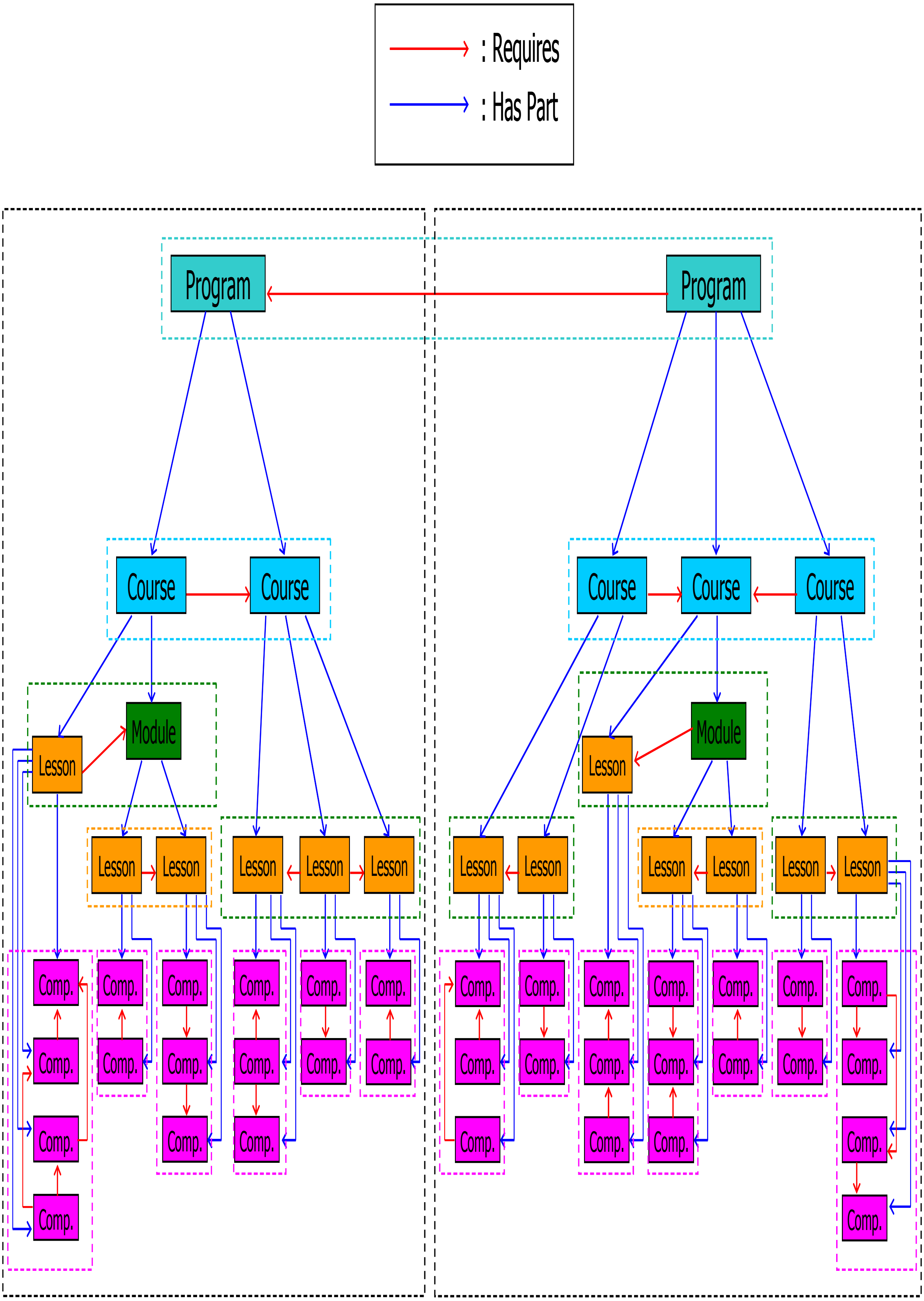



***Figure 6: Example of LO trees and DAGs***

*4)* The *Module to Lessons* level DAG: This DAG contains the *prerequisite* relations among the lessons of the same module. In Figure 6, the two DAGs of this level are represented by orange-colored, dashed rectangles.

5) The *Component* level DAG: This DAG contains the *prerequisite* relations between the components of the same lesson. In Figure 6, the thirteen DAGs of this level are represented by pink-colored, dashed rectangles.

### 3.2.2 ARIADNE Metadata

The European ARIADNE project ran from 1996-2000 and, with IMS (Instructional Management Systems), produced a set of recommendations for educational metadata that helped form the basis of the IEEE LOM. People involved in the ARIADNE project have since founded the ARIADNE Foundation, which seeks to build on the achievements of the original project. This metadata standard is trying to resolve two problems:

1) Easy and efficient indexing of LOs
2) Easy exploitation of the metadata by users looking for relevant pedagogical material.

We are going to present the ARIADNE Metadata Specification v3.2 [2]. According to this specification, there are a number of mandatory categories and an optional category, namely the *Annotations* category. The idea behind ARIADNE making some metadata elements mandatory is to address the conflict that exists between two principles it considers learning object repositories should adhere to:

1) That metadata creation by learning object authors or indexers should be as easy as possible
2) That search for useful learning objects should be as easy as possible.

Thus, the mandatory categories constitute the minimal set of descriptive attributes that should allow for relatively good search capabilities without being too much burden to create. The seven categories of the ARIADNE Metadata Specification v3.2 are shown in Table 4:

| ***CATEGORY*** | ***MANDATORY/OPTIONAL*** |
|---|---|
| ***General information of the resource*** | *Mandatory* |
| ***Semantics of the resource*** | *Mandatory* |
| ***Pedagogical Attributes*** | *Mandatory* |
| ***Technical characteristics*** | *Mandatory* |
| ***Conditions of use*** | *Mandatory* |
| ***Meta-metadata information*** | *Mandatory* |
| ***Annotations*** | *Optional* |

***Table 4: ARIADNE Metadata v3.2 categories***

In the Table above, the categories *Semantics of the resource* and *Pedagogical attributes* are the most important, as long as they describe the pedagogical value of a LO.

#### 3.2.2.1 ARIADNE CS252 example

In order to present ARIADNE's metadata record structure, we present a metadata record of the course CS252 complying with the ARIADNE Metadata v3.2's most significant categories, i.e., *Semantics of the resource* and *Pedagogical Attributes*. This metadata record representation is proportional with the metadata record representation used in the IEEE LOM Final Draft v1.0 example metadata record presented above:

2.1. *Semantics.Discipline Type* "Natural, Exact or Engineer Sciences"
2.2. *Semantics.Discipline* "Computer Science"
2.3. *Semantics.SubDiscipline* "Software Programming"
2.4. *Semantics.Main Concept* "Object Oriented Programming"
2.5. *Semantics.Other Concepts* "JAVA PL"

3.1. *PA.End User Type* "Learner"
3.2. *PA.Document Type* "Expositive"
3.3. *PA.Document Format* "Hypertext"
3.4.1. *PA.Didactical Context.Country* "gr"
3.4.2. *PA.Didactical Context.Context* "University Degree"
3.4.3. *PA.Didactical Context.Level* "2"

PA is the abbreviation of *Pedagogical Attributes*. Didactical Context Level 2 means that CS252 is a second-year course.

| | | |
|---|---|---|
| 3.6. | *PA.Interactivity Level* | "Medium" |
| 3.7. | *PA.Semantic Density* | "High" |
| 3.8. | *PA.Pedagogical Duration* | 4 months in minutes ??? |
| 3.9 | *PA.Granularity* | "Course or Course Template" |

We can note that the differences between the metadata records of ARIADNE and IEEE LOM are imperceptible. However, the pedagogical duration (3.8 *Pedagogical Duration*) of the LO described *must be given in minutes* (!); a fact that causes frustration when finding the duration of LOs of high granularity levels, like courses or programs. Furthermore, an important drawback of the ARIADNE Metadata v3.2 is the lack of support for describing information about the relations of a LO, like *prerequisites*. The relations among LOs are a significant feature that must be included in a metadata record. Therefore, we can assume that ARIADNE v3.2 is not a complete metadata standard.

### 3.2.3 IMS Metadata

The metadata specifications of IMS use exactly the same elements of previous versions of IEEE LOM. The latest version of IMS Metadata specification, v1.2.2 [6], is completely the same with IEEE LOM Working Draft v6 [5]. As we can educe, IMS has the same granularity levels with IEEE LOM.

Due to the large number of IEEE LOM elements, IMS distinguishes two different specifications:

1) IMS *Core* (20 LOM elements, which are a reduced set of fundamental metadata)
2) IMS *Standard Extension Library* or IMS-*SEL* (the remaining LOM elements).

### 3.2.4 SCORM Metadata

ADL's Sharable Courseware Object Reference Model (SCORM) [12] uses IEEE LOM Metadata. It maps IEEE LOM elements into three learning content elements for providing the missing link between general metadata specifications and specific content models. These three learning content elements are considered to be the granularity levels of SCORM, which are from lower to higher:

1) ***Raw media*** (like Components, Fragments)
2) ***Content*** (like Lessons, Modules, Units)

*3)* ***Course***

On the whole, ADL SCORM specifies how a user can build a course by aggregating content objects as a course tree; what is the type of these content objects and how they are launched and interact with a learning management system; and what kind of data content objects exchange within a learning management system. *Sharable Courseware Object Reference Model* (SCORM) was changed to *Sharable Content Object Reference Model* (SCORM) for all versions after 1.0.

## 3.3 Content Structure Modeling

### 3.3.1 AICC

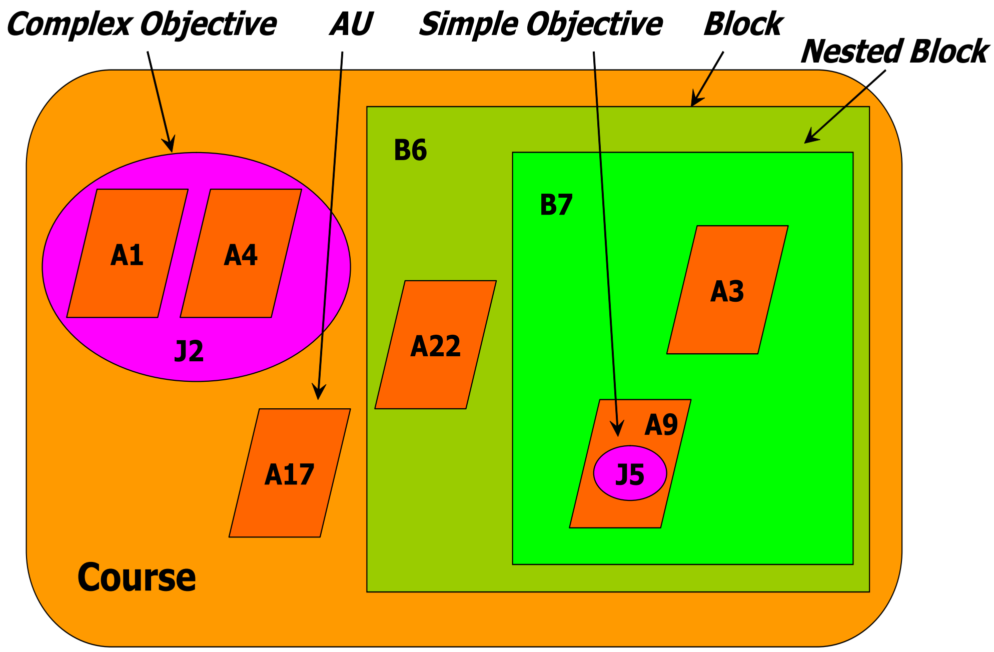
The Aviation Industry CBT Committee (AICC) is an international association of technology-based training professionals, which develops guidelines for aviation industry in the development, delivery, and evaluation of CBT (Computer-Based Training) and related training technologies. In the AICC e-Leaning metadata standard, we can distinguish three types of course elements:

1) ***Assignable Units*** *(AUs),* the smallest educational elements that can be presented to a student, like an HTML page. AUs represent the lessons of a course
2) ***Blocks****,* which are used for nesting. A block can nest AUs and other blocks, which are called *nested blocks*
3) ***Objectives****,* which are used to define course requisites and represent goals that must be achieved in the course. They may be *simple* or *complex* (when they contain simple or multiple AUs and blocks).

From the above course elements, AUs and blocks constitute AICC's structure elements. Objectives are not structure elements.

#### 3.3.1.1 AICC CMI Guidelines for Interoperability

This AICC's specification provides a Content Structure Model used primarily for interoperability. The main idea behind this model is that a course is a collection of Assignable Units (AUs), blocks and objectives. A course example in AICC CMI and the identification of its elements is shown in Figure 7:




| | |
|---|---|
| *Assignable Units* (Ax) | A1, A3, A4, A9, A17, A22 |
| *Blocks* (Bx) | B6, B7 |
| *Objectives* (Jx) | J2, J5 |

***Figure 7: AICC CMI course example (Element identification)***

The *Course Structure* Table of the course in Figure 7 is shown in Table 5. This table does not contain objectives, as long as objectives are not structure elements.

| ***Block*** | ***Member*** | ***Member*** | ***Member*** | ***Member*** | ***Member*** |
|---|---|---|---|---|---|
| Root | B6 | B7 | A1 | A4 | A17 |
| B6 | B7 | A22 | | | |
| B7 | A3 | A9 | | | |

***Table 5: Course Structure Table of Figure 7***

In AICC CMI Guidelines for Interoperability we can define *prerequisites* among the structure elements of a course. For instance, in Figure 7 let AU A4 be a prerequisite of block B6 and B6 be a prerequisite of AU A17. This hypothesis is shown in Figure 8.

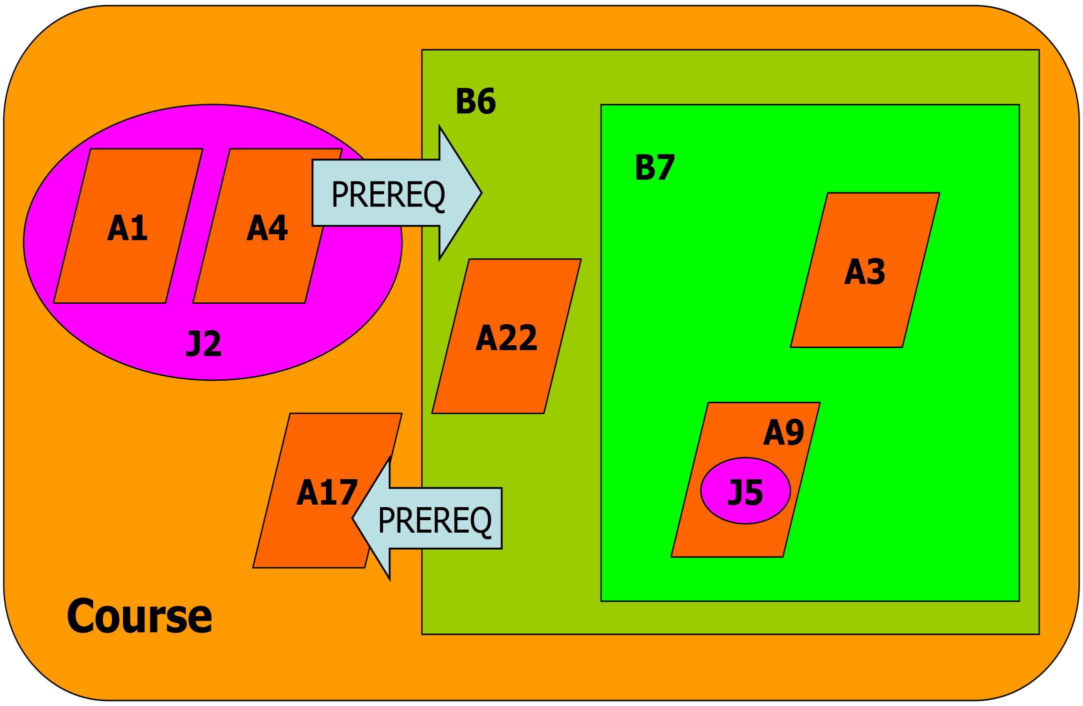



***Figure 8: The course in Figure 7 with prerequisites***

The *Prerequisite Table* of the course in Figure 8 is shown in Table 6.

| ***Structure Element*** | ***Prerequisite*** |
|---|---|
| A22 | A4 |
| A3 | A4 |
| A9 | A4 |
| A17 | B6 |

***Table 6: Prerequisite Table of the course***

As we can observe, in the *Structure Element* column of Table 6, we can only register AUs. In Figure 8, block B6 contains AU A22 and block B7, B7 contains AUs A3 and A9 and AU A4 is a prerequisite of B6, so A22, A3 and A9 have A4 as a prerequisite.

The *Course Structure Table* and the *Prerequisite Table* are two of the files that AICC CMI Guidelines for Interoperability provide for storing the static and dynamic structure of courses exchanged between e-Learning systems. The relation of these files with their type and the corresponding contents is shown in Table 7. When these files are transferred from one platform to other compliant platforms, the course can be straightly recreated.

| ***Name*** | ***Content*** | ***Type*** |
|---|---|---|
| *Course* | *Basic information about a course, including a textual description* | *Group/*<br>*Keyword* |
| *Descriptor* | *System generated IDs, title and descriptions of each element in a course: AUs, Blocks, Objectives and Complex Objectives* | *Table* |
| *Assignable Unit* | *Information about each AU, including data needed to launch it* | *Table* |
| *Course Structure* | *Static Course Structure Table* | *Table* |
| *Objectives Relationships* | *Shows the relationship (if any) of each objective in a course to other objectives, blocks and AUs* | *Table* |
| *Prerequisite* | *Prerequisite Table. It indicates prerequisites for entering each AU* | *Table* |
| *Completion Requirements* | *Completion Table. It indicates the requirements for completion of each block or complex objective whose completion cannot be determined by the defaults* | *Table* |

***Table 7: AICC CMI Course Structure Files***

#### 3.3.1.2 AICC Granularity Levels

In order to avoid inconsistency due of the ability of multiple nesting (blocks into blocks into blocks etc.), AICC has established a reference hierarchy with ten levels. These levels, shown in Table 8, are considered to be the AICC *granularity levels*.

| | |
|---|---|
| ***First level (higher)*** | ***Curriculum***, a grouping of related courses |
| ***Second level*** | ***Course***, a complete unit of training |
| ***Third level*** | ***Chapter***, a meaningful division of a course. A grouping of subchapters or lessons (high level *block*) |
| ***Fourth level*** | ***Subchapter***, a meaningful division of a chapter. A grouping of lessons or modules (middle level *block*) |
| ***Fifth level*** | ***Module***, logical group of lessons (one or more). A meaningful division of a course, chapter or subchapter (low level *block*) |
| ***Sixth level*** | ***Lesson/AU***. Has three meanings :<br>1. A meaningful division of learning that is accomplished by a student in a continuous effort |

| | |
|---|---|
| | 2. A grouping of instruction that is controlled by a single executable computer program<br>3. A unit of training is a logical division of a subchapter, chapter or course |
| ***Seventh level*** | ***Topic***, logical divisions of a lesson |
| ***Eighth level*** | ***Sequence*** |
| ***Ninth level*** | ***Frame/Screen*** |
| ***Tenth level (Lower)*** | ***Object***, component of a screen or frame |

***Table 8: AICC Granularity Levels***

In Table 8, the *Sequence* and *Frame/Screen* levels are mainly focused in technical specifications of LOs. We can observe that AICC respects the general granularity hierarchy of LOs. Also, we can assert that *Chapters, Subchapters* and *Modules* are essentially the "new" names of the AICC's *blocks.*

#### 3.3.1.3 AICC versus IEEE LOM

Table 9 shows the granularity levels that the AICC and IEEE LOM (respectively and IMS) specifications use in several LO functions.

| ***Function*** | ***AICC*** | ***IEEE LOM (IMS)*** |
|---|---|---|
| *Outer Container* | *Course* | *Course* |
| *Nesting Container* | *Block* | *Unit* |
| *Content Aggregate* | *AU* | *Lesson* |
| *Reusable Media Element* | *Object ?* | - |

***Table 9: AICC vs. IEEE LOM LO Granularity***

We can observe that there is an analogy between the granularity levels used by AICC and IEEE LOM in the three first functions. As we have already mentioned, AICC's *Blocks* and IEEE LOM's *Units* represent *Modules* in the general granularity hierarchy of LOs. Also, *AUs* represent *Lessons* in AICC, so the correspondence is obvious. In LO function *Reusable Media Element*, AICC is considering using *Objects*, while IEEE LOM has not made a suggestion till now.

### 3.3.2 SCORM Content Structure Format (CSF)

SCORM CSF [12] is derived from AICC CMI, but it is slightly differentiated. In particular,

- SCORM CSF is applicable not only to complete courses, but also to subsets of courses or to groups of courses
- SCORM CSF renames the term *AU* to *Sharable Content Object (SCO)*, but preserves its meaning.

The main elements of SCORM CSF's DTD, are shown in Figure 9:

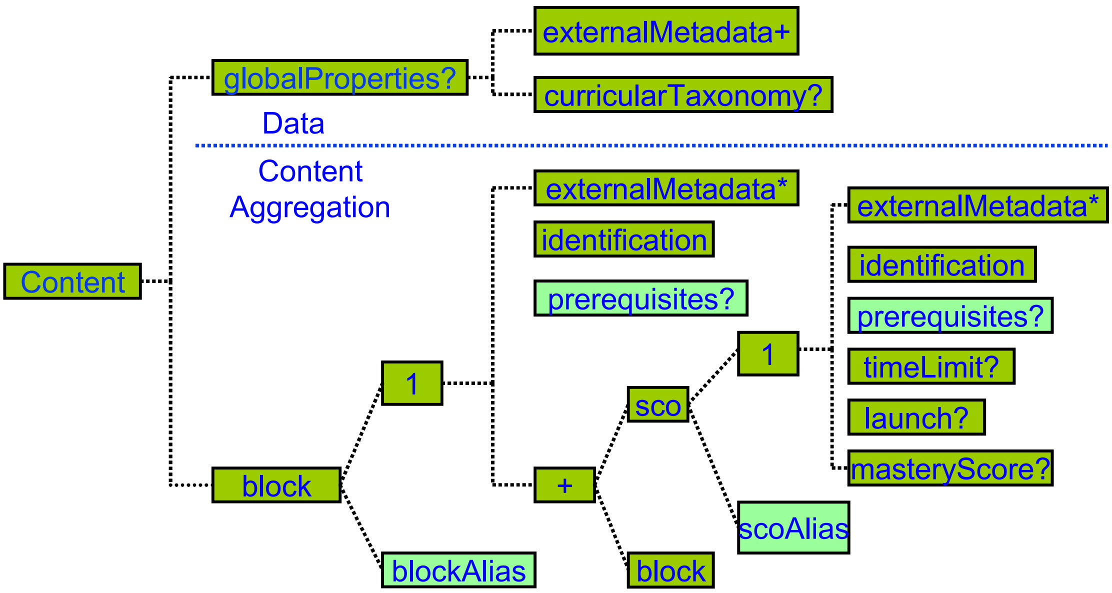



***Figure 9: SCORM CSF's DTD (Main elements)***

The definitions of these elements are given below:

- *Content* element: The root level of *Content Structure* representation. This element reproduces the learning content being structured
- *globalProperties* element: The properties of the learning content as whole
- *block* element: A grouping of related structural elements. *Blocks* always contain other learning content elements
- *externalMetadata* element: The value of this element refers or points to the location of the metadata describing this learning content
- *curricularTaxonomy* element: The organizational methodology used to construct the learning content
- *identification* element: This element identifies the learning content context-specific information

- *prerequisites* element: An expression indicating what a student must have accomplished before beginning the learning content element. That is, the learning content elements that a student must complete before beginning a block or a SCO. This element constitutes the standard way SCORM CSF defines LO prerequisites
- *sco* element: Like AU, SCO is the smallest element of instruction or testing presented to a student
- *blockAlias* element: A reference to a previously defined block. This element permits one block to be used more than once within a learning content
- *scoAlias* element: A reference to a previously defined *sco*. This element permits one SCO to be used more than once within a learning content
- *timeLimit* element: The time values or actions associated with this *sco* in this context
- *launch* element: The information needed by a Learning Management System (LMS) to launch a *sco*
- *masteryScore* element: The values to be used in this learning content context for tracking score within a *sco*

As we can observe from Figure 9:

- The *Content* element could be a course, a subset of a course or a group of courses
- The *globalProperties* element contains the data about the *Content* element
- The *block* element defines the structure of the *Content* aggregation
- A *Content* element constitutes one *block* element and zero or one *globalProperties* element (we have a question mark (?) in *globalProperties* element)
- The *sco* element constitutes a *scoAlias* element or an element which constitutes zero or multiple *externalMetadata* elements, one *identification* element and zero or one *prerequisites, timeLimit, launch* and *masteryScore* elements
- The green highlighted boxes represent the elements that lead us to the distinction of the existing relations between LOs in SCORM CSF. These are the *prerequisite* relation (the *prerequisites* element) and the *reference* relation (the *blockAlias* and *scoAlias* elements).

The most significant observation made from Figure 9 is the frequent use of the *prerequisite* relation between LOs. This is very important as in real practise, learning contents usually have prerequisites or are prerequisites of other learning contents

### 3.3.3 IMS CP Information Model

For Content Structure Modelling, IMS provides the IMS CP Information Model [7, 8, 9]. This model:

- Is based on a set of data structures to provide content interoperability in an Internet environment
- Encapsulates a complete course, with its related metadata, in a single file
- Is very flexible in the representation of the learning content
- Co-operates significantly with the other organizations.

The key element of this model is the *package*. Figure 10 shows a pictorial representation of IMS CP Information Model.

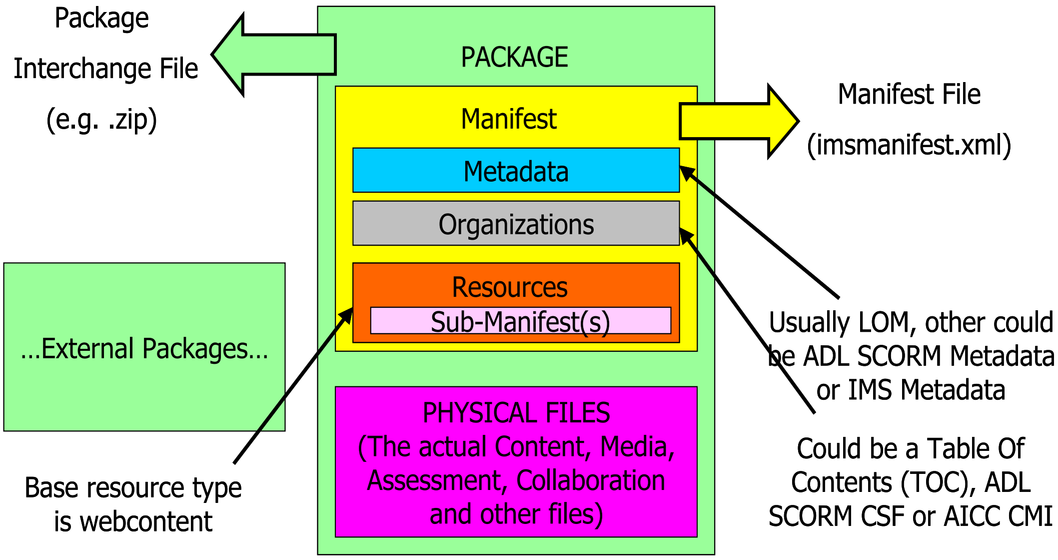



***Figure 10: IMS CP Information Model***

In IMS CP Information Model, the *Package* element contains two main elements:

- A *manifest* element, an XML document with stable name (*imsmanifest.xml*) that describes the encapsulated contents and their organizations
- The *actual educational contents*, described in the *manifest*, such as media and text files, assessment objects or other data pieces in file form.

The *Manifest* element consists of:

- *Metadata:* An XML element describing the *manifest* as a whole. For the metadata description, we can use IEEE LOM, IMS Metadata, SCORM Metadata or other metadata standards
- *Organizations:* An XML element describing zero, one or multiple static ways of organizing (aka, structuring) the instructional resources for presentation. For the structuring, we can use Table Of Contents (TOC), AICC CMI, SCORM CSF or other
- *Resources:* A section which contains references to all of the actual resources and media elements needed for a manifest, including metadata describing the resources, references to any external files and sub-manifests that can contain zero, one or multiple logically nested manifests.

*Manifest* has flexible scope and facilitates aggregation or unfolding. A package always contains a top-level manifest that can include sub-manifests associated to a part of the contents encapsulated into this package. For example, a content developer who wants to move multiple courses could create a manifest for each course and then aggregate all of them in a single package, with a top-level manifest describing the collection of courses as a curriculum.

*Packages* can be interpreted as logical directories, which contain:

- A manifest file (*imsmanifest.xml*)
- All format control documents for the manifest (e.g., DTD, XSD)
- A set of sub-directories containing the physical files
- The single file (e.g., .zip), where the logical directory of the *package* is placed, is named *Package Interchange File.*

#### 3.3.3.1 IMS CP Information Model CS252 Example

This subsection provides a metadata record of the *Manifest* of CS252 in IMS CP Information Model v1.1.2 [8]. For this record, we are using the IMS CP Schema v1.1 [9]. IMS CP Information Model v1.1.2 is not the latest version, as IMS CP Information Model v1.1.3 [7] has already been released. Instead for an XML document of the *Manifest* metadata record, we follow the same presentation style used for the Metadata records of IEEE LOM and ARIADNE above.

0.1. *Manifest.Identifier* The unique ID of this manifest (e.g., MANIFEST-CS252)

1.1. *Metadata.Schema* "IMS Content" (IMS CP Schema)
1.2. *Metadata.SchemaVersion* "1.1"
1.3. *Metadata.{IMS Metadata}* The IMS Metadata describing CS252 (e.g., LOM 1.0 or IMS 1.2.2)

2.2.1. *Organizations.Organization.Identifier*
The unique ID of this organization element (e.g., TOC1)

2.2.3. *Organizations.Organization.Title* "Lectures"

As we can notice, CS252 comprises a Table Of Contents (TOC) called "Lectures" that contains the lessons of this course. Next, we present the annotation of the lessons constituting the TOC "Lectures".

Caution: Org is the abbreviation the Organization element.

2.2.4.1. *Organizations.Org.Item.Identifier*
The unique ID of this item (e.g., TOC1_ITEM1)
2.2.4.2. *Organizations.Org.Item.IdentifierRef*
The reference to the ID of this item in the *Resources* section (e.g., TOC1_RESOURCE1)
2.2.4.3. *Organizations.Org.Item.Title*
"Introduction: Programming Languages and Paradigms"

2.2.4.1. *Organizations.Org.Item.Identifier* TOC1_ITEM2
2.2.4.2. *Organizations.Org.Item.IdentifierRef* TOC1_RESOURCE2
2.2.4.3. *Organizations.Org.Item.Title*
"Java Programming Basics: Types, Variables, Operators"

2.2.4.1. *Organizations.Org.Item.Identifier* …
2.2.4.2. *Organizations.Org.Item.IdentifierRef* …
2.2.4.3. *Organizations.Org.Item.Title* …

2.2.4.1. *Organizations.Org.Item.Identifier* …
2.2.4.2. *Organizations.Org.Item.IdentifierRef* …
2.2.4.3. *Organizations.Org.Item.Title* …

Now, we are going to define the second TOC used in CS252, named "Assisting Lectures", which contains the assisting lessons of CS252. After this action, we import the lessons that constitute this TOC in a similar way as previously.

2.2.1. *Organizations.Org.Identifier*
The unique ID of this organization element (e.g., TOC2)
2.2.3. *Organizations.Org.Title* "Assisting Lectures"

2.2.4.1. *Organizations.Org.Item.Identifier* TOC2_ITEM1
2.2.4.2. *Organizations.Org.Item.IdentifierRef* TOC2_RESOURCE1
2.2.4.3. *Organizations.Org.Item.Title*
"The Java Programming Environment"

2.2.4.1. *Organizations.Org.Item.Identifier* TOC2_ITEM2
2.2.4.2. *Organizations.Org.Item.IdentifierRef* TOC2_RESOURCE2
2.2.4.3. *Organizations.Org.Item.Title*
"Files, Streams, Filters and Strings"

2.2.4.1. *Organizations.Org.Item.Identifier*
2.2.4.2. *Organizations.Org.Item.IdentifierRef* …
2.2.4.3. *Organizations.Org.Item.Title* …

After declaring the main and assisting lessons of CS252, we are going to declare the references to them, using the *IdentifierRef* records defined above. This action takes place in the *Resources* section.

3.1.1. *Resources.Resource.Identifier* TOC1_RESOURCE1
3.1.2. *Resources.Resource.Type* "webcontent"
3.1.3. *Resources.Resource.HRef*
"http://www.csd.uoc.gr/~hy252/lectures/CS252Intro.pdf"

3.1.1. *Resources.Resource.Identifier* TOC1_RESOURCE2
3.1.2. *Resources.Resource.Type* "webcontent"
3.1.3. *Resources.Resource.HRef*
"http://www.csd.uoc.gr/~hy252/lectures/CS252Basics.pdf"

3.1.1. *Resources.Resource.Identifier* TOC2_RESOURCE1
3.1.2. *Resources.Resource.Type* "webcontent"
3.1.3. *Resources.Resource.HRef*

"http://www.csd.uoc.gr/~hy252/assist/CS252JavaProgrammingEnvironmen t.pdf"

3.1.1. *Resources.Resource.Identifier* TOC2_RESOURCE2

3.1.2. *Resources.Resource.Type* "webcontent"

3.1.3. *Resources.Resource.HRef*

"http://www.csd.uoc.gr/~hy252/assist/streams_files.pdf"

3.1.1. *Resources.Resource.Identifier* …

3.1.2. *Resources.Resource.Type* …

3.1.3. *Resources.Resource.HRef* …

The *webcontent* type is the only current type supported by IMS CP Information Model v1.1.2. It is defined as the content that can be hosted or launched by an Internet Browser.

# 4. Conclusions

In this report, we overviewed the main aspects which characterize a LO in e-Learning environments, namely LO *definition*, LO *granularity* and LO *conceptual representation*. E-Learning standards have been developed to describe LOs and their relationships. Thus, we also introduced the main e-Learning standards that focus on the two primary LO conceptual representation layers: *Metadata* and *Content Structure Modelling*. For instance, the most significant metadata standard, IEEE LOM, specifies a variety of *bibliographic* and *technical properties* of LOs, *different relationships among LOs* and enables metadata-based exchange, reuse and search of LOs. However, even though IEEE LOM standard includes an educational category, no information is included to specify which instructional roles are or can be played by a LO within a course. It specifies properties only at a very basic abstraction level and does not support instructional design, like metadata about *instructional models* and *theory* and information about the *use* of LOs in *learning processes*. Thus, IEEE LOM concentrates on *what* should be taught and *when,* rather than *how* to be taught.

In fact, instructional principles are *not* addressed so far by the e-Learning standards introduced above, so students *cannot* choose courses or lessons in a meaningful way. A standard for learning objects metadata should not only tell how to teach, but it should be able to provide information on *how* to specify pedagogical aspects of LOs. Specifying the author and the title of a LO is an *easy* way, but specifying instructional metadata, models and theory is a *better* way. If learning objects are marked-up with sufficiently detailed pedagogic metadata (e.g., "this learning object is particularly useful for helping visual learners grasp such-and-such a concept"), and learners have profiles that match up with this (e.g., "this person learns things best when they are presented visually"), then a search utility over a learning object repository should be able to match users' learning styles as well as the content they require.

The Educational Modeling Language[15] (EML) proposed by the Open University of Netherlands has been recently chosen by IMS as the basis of the newly established Learning Design Specification[16] with aim "*the development of a framework that supports pedagogical diversity and innovation, while promoting the exchange and interoperability of e-learning materials*". EML extends IEEE LOM and all other specifications by explicitly applying educational models and theories of learning on

[15] http://eml.ou.nl

LOs and by providing pedagogical roles for the users. Thus, EML and Learning Design Specification seem to provide the educational context that is lacking in current e-Learning metadata specifications.

Another aspect not confronted by existing e-Learning metadata standards is how to *trust* and *evaluate* the source of LOs. Due to the proliferation of educational material, it is a challenge to build on a web of trust that would enable students to evaluate and credit the authority and authenticity of educational material or annotate all kinds of LOs according to their perception of its value. Furthermore, something, which is also not covered by metadata standards, is the *copyright* aspect. The IEEE LOM standard does not support the specification of usage rights; instead digital rights languages, such as the Open Digital Rights Language[17] (ODRL) and Digital Object Identifier (DOI)[18] could be incorporated into metadata specifications for this particular purpose. The ODRL specification supports an extensible language and vocabulary (data dictionary) for the expression of terms and conditions over any content including permissions, constraints, obligations, conditions, and offers and agreements with rights holders. On the other hand, DOI is a system for identifying and exchanging intellectual property in the digital environment by providing a framework for managing intellectual content, for linking customers with content suppliers, for facilitating electronic commerce, and enabling automated copyright management for all types of media. Using digital management to protect the copyright of learning objects in an efficient way is an issue that calls for research activity.

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[17] http://odrl.net/
[18] http://www.doi.org/

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[13] Bernd Simon, *Do e-Learning standards meet their challenges?*. In Proceedings des Workshops "Standardisierung im eLearning", Frankfurt, Deutschland, April, 2002.

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# Appendix- User Profiles and Personalization

The personalization of access to learning objects, including the necessary semantics of a user profile used to select relevant educational material, is an aspect that stands in need of -even brief- reference. Regardless of the methods used to store personal profiles, we will need to identify the information that will be most useful in personalizing learner's search and access to learning objects. This must include information concerning, for instance, preferred learning styles, current levels of attainment, learning goals, interests, locality information, languages and learning history. User profiles should adapt and expand over time as users interact with the system, and as learning objectives become skills that have been gained. The purpose of this appendix is to approach the issue of learning object personalization by presenting some existing standardization efforts for creating and managing user profiles. Some of these specifications may be useful as a basis for the user profiles used in the context of SeLeNe.

## 1. vCard

The vCard schema for personal (and business) information covers the "basics" of personal information[19] by holding the kind of information usually found on a business card -name, address, date of birth, e-mail address, etc. However, it lacks the information needed to do any useful personalization of access to learning objects. Thus, it constitutes a standards-based specification worth using only as a basis for user profiles.

## 2. IEEE LTSC Personal and Private Information (PAPI) draft standard

The PAPI standard[20] specifies both the syntax and semantics of a "Learner Model", which is used to characterize a teacher or learner. It holds information about, e.g., learning styles, existing skills and abilities, as well as basic personal information and allows the definition of elements at many levels of granularity. This specification is definitely worth looking at in more detail in the context of SeLeNe, as it may have all the elements we will want in a user profile to help personalize access to learning

[19] The RDF representation of this schema is accessible at http://www.w3.org/TR/vcard-rdf
[20] http://ltsc.ieee.org/wg2/papi_learner_07_main.pdf

objects. Details of the possible encodings of the PAPI data need to be explored (specifically, the possibility of using RDF [10, 3]).

## 3. eduPerson

EduPerson is a scheme used by US universities to enable transfer of information about people involved in higher education (both staff and students). Compared to vCard, it specifies some additional attributes, such as affiliation, description, entitlement and preferred language. Although SeLeNe profiles will need to hold some of this information, eduPerson is primarily a US innovation that adds little to the vCard standard.

## 4. IMS Learner Information Package (LIP)

A LIP[21] stores data about learners in eleven categories. The data stored is supposed to aid “recording and managing a learning related history, engaging a learner in a learning experience and discovering learning opportunities for learners”. Thus, this specification is also worth looking at in the context of SeLeNe.

## 5. Universal Learning Format

ULF[22] is a specification developed by Saba Software. Based on the Dublin Core, vCard and other educational metadata standards, it describes both learning content and learners themselves (so it could have been mentioned in section 3.2 on existing metadata standards). Formats are defined for competencies, profiles and certification. RDF is used for resource description and discovery -although it is a proprietary specification it may be worth looking at in the context of SeLeNe.

The above standards are just indicative of the effort to provide users with enhanced learning experience via the personalization of the learning content and its presentation to them.

[21] http://www.imsproject.org/profiles/lipbest01a.html
[22] http://www.saba.com/standards/ulf/Pdf/ulfOverview.pdf