Towards a Global Component Architecture for Learning Objects: A Comparative Analysis of Learning Object Content Models

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Abstract: This paper investigates basic research issues that need to be addressed in order to reuse learning objects in a flexible way. We review a number of learning object content models that define learning objects and their components in a more or less precise way. A comparative analysis is made of these models in order to address questions about repurposing learning objects in a different context. The content models are mapped on our general model for learning objects to facilitate the comparison.

1. Introduction

Learning objects are often regarded as traditional documents. We can reuse a paragraph or a sentence of a document by copy and paste in new and different documents. However, it is possible to reuse learning objects in a much more sophisticated way, if we can access the components of a learning object and repurpose them on-the-fly. However, this requires a more innovative and flexible underlying model of learning object components. In order to put such an approach into effect, some basic research issues need to be addressed (Duval & Hodgins 2003).

According to the Learning Object Metadata (LOM) standard, a learning object is 'any entity, digital or non-digital, that may be used for learning, education or training' (Duval 2002). However, this definition allows for an extremely wide variety of granularities (Duval & Hodgins 2003). Learning object content models address this problem. Content models identify different kind of learning objects and their components. They provide a more precise definition of what learning objects are and allow us to identify learning object components and repurpose them. There exist a number of learning object content models, for example the SCORM Content Aggregation Model (Dodds 2001) and the CISCO RLO/RIO Model (Barrit et al. 1999). A first basic research issue concerns the comparative analysis of these models. The definition of a learning object by SCORM differs from that of CISCO. It is not clear whether a SCORM learning object or component can be repurposed within a CISCO context. To answer this question, a number of content models are investigated in this paper.

Six potential learning object content models were found for inclusion in the analysis. Inclusion or exclusion was decided on the basis of whether all data, needed for the comparison, were published. The following models are included in this survey: the Learnativity content model (Wagner 2002), the Microsoft model (Elliot), the ADL academic co-lab model (Brown 2002), the SCORM content aggregation model (Dodds 2001), the CISCO RLO/RIO model (Barrit et al. 1999) and the NETg learning object model (L'Allier 1997).

In the following sections, we first briefly outline each model that is included in this survey to give a general idea of the model. Then the models are compared with one another. A new, general content model is developed and existing content models are mapped to this model to facilitate a comparative analysis. Conclusions and future work conclude this paper.

2. Overview of Learning Object Content Models

2.1 Learnativity Content Model

The learnativity content model (Wagner 2002) identifies the following taxonomy:

1. *Raw Media Elements* are the smallest level in this model: these elements reside at a pure data level. Examples include a single sentence or paragraph, illustration, animation, etc.

2. *Information Objects* are sets of raw media elements. Such objects could be based on the "information block" model developed by Horn (Horn 1998).

3. Based on a single objective, information objects are then selected and assembled into the third level of Application Specific Objects. At this level reside *learning objects* in a more restricted sense than the aforementioned definition of the LOM standard suggests.

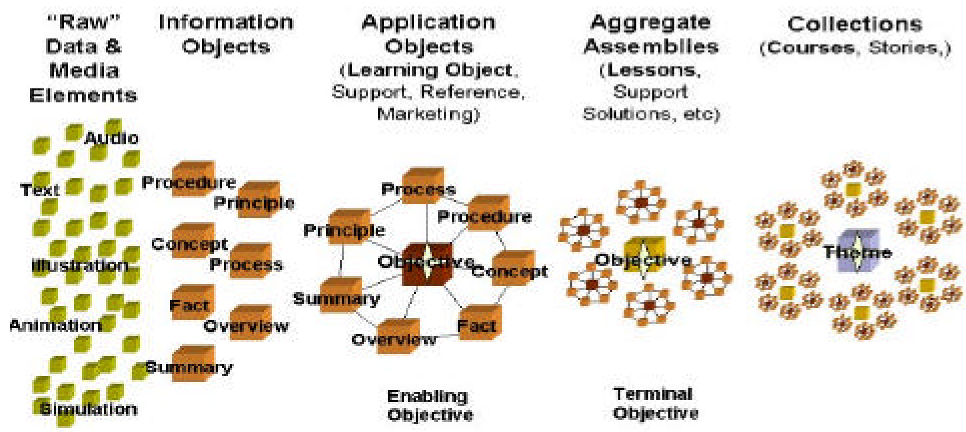

Figure 1: Learnativity Content Model (Duval & Hodgins 2003)

4. The fourth level refers to *Aggregate Assemblies* that deal with larger (terminal) objectives. This level corresponds with more conventional lessons or chapters.

5. Lessons or chapters can be assembled into larger collections, like courses and whole curricula. The fifth level refers to these *Collections*.

Clearly, information objects contain raw media elements. Learning objects contain information objects. Aggregate assemblies contain learning objects and other aggregate assemblies. The Microsoft Model (Elliot) and the Academic Co-lab Model (Brown 2002) are variants of this content model.

2.2 SCORM Content Aggregation Model

The SCORM content aggregation model (Dodds 2001) contains the following components: Assets, Sharable Content Objects (SCO) and Content Aggregations. Assets are an electronic representation of media, text, images, audio, web pages or other data that can be presented in a web client. A Sharable Object (SCO) represents a collection of one or more assets. To improve the reusability, a SCO should be independent of its learning context. A SCO can for example be reused in different learning experiences to fulfill different learning objectives. SCOs are meant to be small units, such that reusability in more learning objectives is feasible. A Content Aggregation is a map (content structure) that can be used to aggregate learning resources in a well integrated unit of education (for example course, chapter, module, ...).

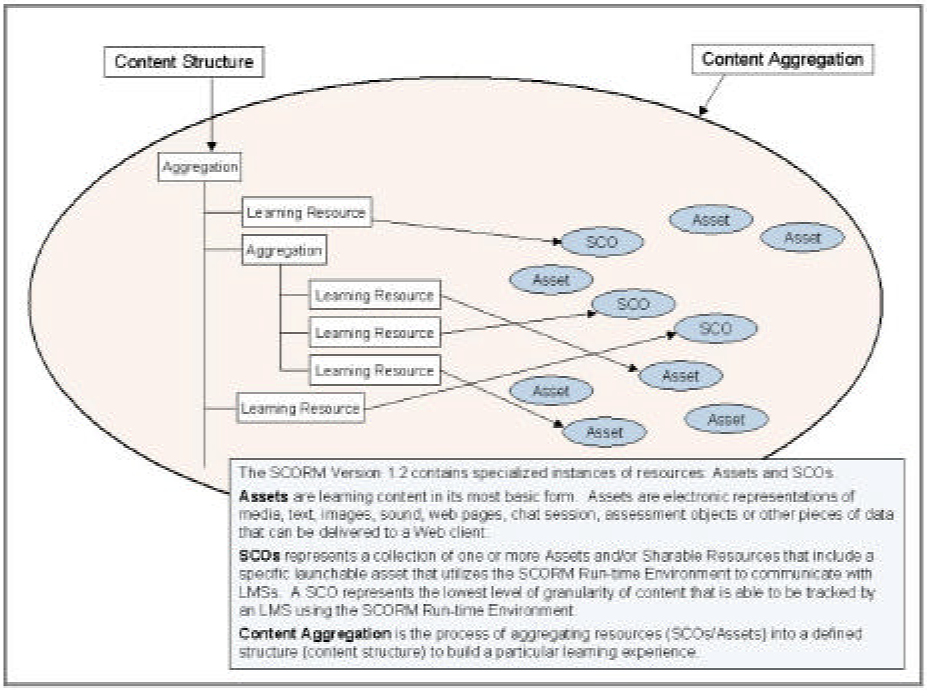

Figure 2: The SCORM Content Aggregation Model (Dodds 2001)

2.3 CISCO RLO/RIO Model

A Reusable Learning Object (RLO) is a collection of 7 ± 2 RIOs (Reusable Information Objects). To make a complete learning experience or lesson from a collection of RIOs, an Overview, Summary and Assessment are added to the packet.

Reusable Information Objects (RIOs) are pieces of information that are built around a single learning objective. Each RIO is composed of three components: content items, practice items and assessment items. A practice item is an activity that gives the learner the ability to apply its knowledge and skills, like a case study or a practice test. An assessment item is a question or measurable activity used to determine if the learner has mastered the learning objective for a given RIO.

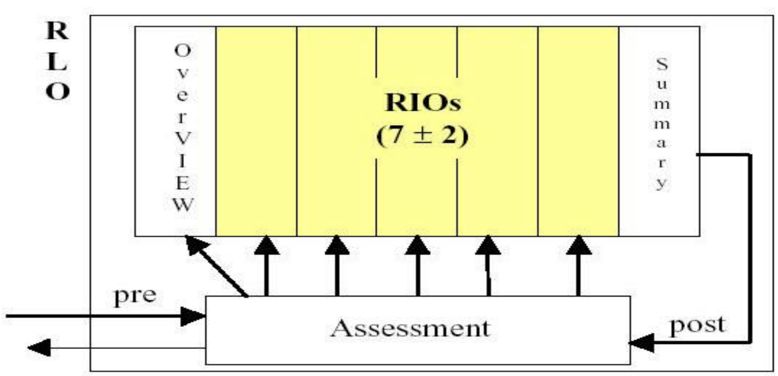

Figure 3: CISCO RLO/RIO Model (Barrit et al. 1999)

2.4 NETg Learning Object Model

NETg was one of the first to use the LO concept for its IT courses. It has a hierarchy of 4 levels – course, unit, lesson and topic. A course contains independent units. A unit contains independent lessons and a lesson contains independent topics. A topic represents an independent learning object that contains a single learning objective and has a corresponding activity and assessment (L'Allier 1997).

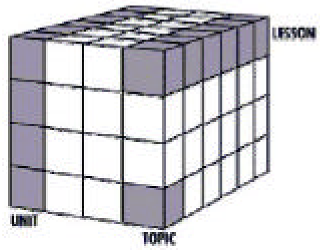

Figure 4: NETg Learning Object Model (L'Allier 1997)

3. Towards a Comparative Analysis of Learning Object Content Models: a new Model

In this section, we introduce a new, general model for learning objects. The purpose is to map different content models to this model, in order to facilitate a comparative analysis. Figure 5 represents the model.

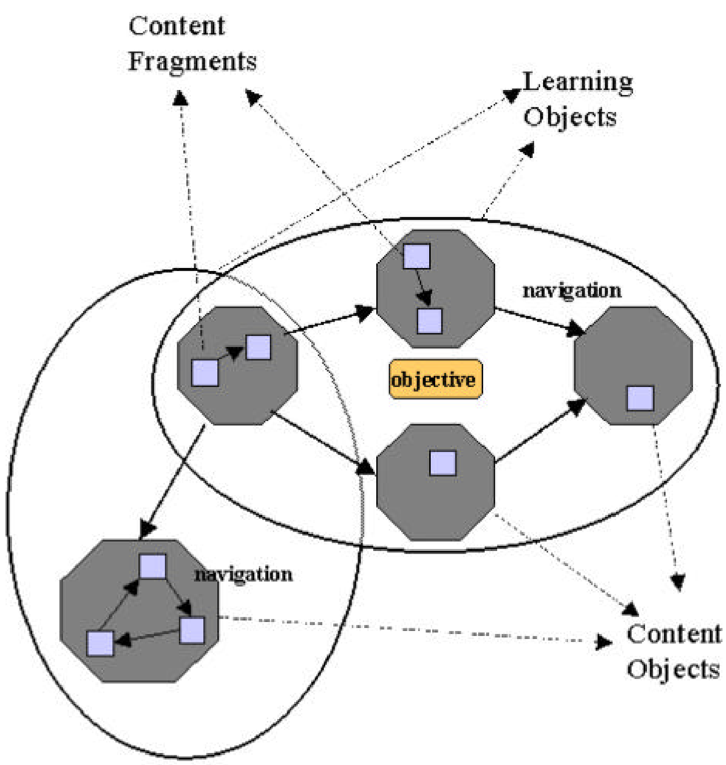

Figure 5: General Learning Object Content Model

We distinguish between content fragments, content objects and learning objects. Content fragments are learning content elements in their most basic form, like text, audio and video. They represent individual resources uncombined with any other. A further specialization of this level will need to take into account the different characteristics of time-based media (audio, video and animation) and static media (photo, text, etc.). Content objects are sets of content fragments. They aggregate content fragments and add navigation. Content fragments are instances, whereas content objects are abstract types. We can extend content fragments with activities and people, and analogously content objects with activity types and roles. A content object assembles also other content objects. At the next level, learning objects aggregate instantiated content objects and add a learning objective. They define a topology between their components and can communicate with the outside world. Aggregations of learning objects can be made. We do not specify the number of aggregation levels. It seems rather arbitrary to specify 3 or maybe 4 levels of aggregation.

Briefly stated, learning objects contain content objects, zero or more other learning objects and a learning objective. A content object contains content fragments, zero or more content objects and navigation. Navigation may not be confused with presentation, like formatting and layout. Content fragments, content objects and learning objects have metadata. Metadata provides guidance to describe learning objects and their components in a consistent fashion, facilitating sharing and reuse of both learning objects and their components.

We can now try to map existing learning content models on this model:

- CISCO identifies RIOs, assessments, overviews and summaries, which can be mapped on content objects. An RLO is an aggregation of these components. As a result, the CISCO RLO/RIO Model fits within the constraints of our model. The CISCO RLO/RIO model can be viewed as a specific profile of our model. It defines the components of a learning object more strictly: the model specifies that a learning object (RLO) contains 7 ± 2 RIOs, whereas the presented model does not restrict (the number of) components of a learning object.

- Within the SCORM aggregation model, an asset can be associated with a content fragment. It is not clear where we should situate an SCO. SCOs are self-contained units of learning and communicate with an LMS. Furthermore, SCOs represent a collection of assets and can consequently be mapped on a learning object. On the other hand, SCOs cannot be broken down into smaller units. From this point of view, SCOs can be associated with content objects and content aggregations can be mapped on learning objects. In both ways, the SCORM content aggregation model fits within the constraints of the presented model.

- The leamativity model maps easily on the represented model. Raw media elements are associated with content fragments. Information objects like processes and procedures are abstract types like content objects. Learning objects and aggregations fit within the represented model. The three aggregation levels of the learnativity model (learning objects, aggregate assemblies and collections) come together in our model. The restriction of three levels of aggregation in learnativity seems very arbitrary.

- NETg uses the term learning object, but applies a three-part definition: a learning objective, a unit of instruction that teaches the objective, and a unit of assessment that measures the objective. These are abstract types, which can be mapped on content objects. NETg defines aggregations that fit within the constraints of our model. The NETg model specifies aggregations in more specific levels. The four levels of aggregation in NETg (topic, lesson, unit and course) come together in our model. The restriction of four levels of aggregation seems very arbitrary.

More generally, we can say that the various models fit within the constraints of our model. Each model is more or less a specific profile of the presented model. Table 1 summarizes this information.

Model	Content fragments	Content Objects	Learning object			
Learnativity	Raw Media	Information Object	Learning Object	Aggregate Assemblies	Collections	
SCORM	Assets		SCO	Content Aggregation		
CISCO	Content Items	RIO	RLO			
Netg			Topic	Lesson	Unit	Course

Table 1: Summary of Learning Object Content Models

Now we can answer questions about the homogenity of the different learning object content models. It is obvious that a learning object of a model can be used in another model if the learning object is in a subset of both models. For example, a learnativity learning object can be used in CISCO if it contains 7 ± 2 information objects, an overview, summary and assessment. If the learning object contains only 4 RIOs, it is not in a subset of both profiles and cannot be used within a CISCO context. A learning object of CISCO fits within the NETg model if the RLO contains a single learning objective and has a corresponding activity and assessment.

4. Conclusions and Future Work

We developed an abstract model that roughly outlines learning objects and their components. Much more detail is required in order to develop a flexible architecture that enables on-the-fly composition of learning objects and interactions between the different components. We are currently investigating an ontology based approach (Qin & Finneran 2002) to further detail and operationalize our model.

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Acknowledgements

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