A Comparison between Sharable Content Object Reference Model and Individually Adaptive Learning Management System Model

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Key Words: *SCOR; Individually Adaptive Learning Management System Model.*

Abstract. *Sharable Content Object Reference Model (SCORM) is compared to the Individually Adaptive Learning Management System Model (IALMSM) developed by the authors. The comparison investigates the particular realization of the main points of a generalized learning management system model and also the specific approaches the two models expose. SCORM is flexible, diverse, highly generalized, complex and rich in definitions and parameters. It allows the presentation and implementation of a broad variety of educational content structures and strategies. IALMSM offers still highly generalized model for sequencing but has compact approach to the sequencing realization, although based on the same block structure paradigm. IALMSM offers the session attempt approach in contrast to learning activity attempt approach implemented in SCORM. The use of a system specific formal language aims at investigating the concept of a direct and specific formalization of the learning content and adaptive behavior strategies seeking a higher level of language simplicity and specificity.*

1. Introduction

There are several major goals when defining a learning management system (LMS) model such as the Sharable Content Object Reference Model (SCORM) or Individually Adaptive Learning Management System Model (IALMSM). Some of the most important issues are, first, to articulate guidelines, which will be understood clearly and implemented easily by developers of e-learning content. Second, the model must be approved and utilized by as many users, organizations and institutions as possible. Third, it must assure implementation of any possible (or most possible) e-learning scenarios for design of tutoring systems. And finally, the aim of the modern e-learning systems and models is the individual and adaptive approach the system will conduct towards the learner.

Defining and developing such models has a number of benefits for the learning practices as most noticeable being the decreased costs and achieved higher levels of accessibility, reusability, durability and interoperability of the e-learning process.

In the present article, two models are investigated and a comparison between their major features is conducted in regard to the personal user learning process individualization and adaptation concept of the e-learning activity. A full-features parallel between the two system models is beyond the scope of the current article.

The well-known Sharable Content Object Reference Model and the developed by the authors Individually Adaptive Learning Management System Model are compared.

2. SCORM Overview

In November 1997 the United States Department of Defense (DoD) and the White House Office of Science and Technology Policy (OSTP) initiated the Advanced Distributed Learning Initiative (ADL). The major aim of this program was to provide access to highest-level quality learning, delivered anytime and anywhere with high cost-efficiency.

As a result of accomplishment of these goals, ADL's SCORM was formed. This model targets the creation of reusable learning content consisting of instructional objects delivered in a technical framework environment for Web-based and computer-based tutoring.

SCORM encompasses several interrelated technical standards, guidelines and specifications designed to respond to the higher-level requirements that e-learning systems expose. SCORM delivers a coordinating model consisting of standard practices that can be generally implemented and widely accepted by the e-learning community. The model also assists in technical foundations for the development of the Web-based learning environment. SCORM defines a „Content Aggregation Model", a „Run-Time Environment" and a „Sequencing and Navigation" model for the dynamic presentation of content based on learner needs [1].

Another important initiative of SCORM is to tie together the achievements of different teams and groups of interests in the distributed learning community. Thus the model intends to coordinate new e-learning technologies and their public and commercial implementations.

SCORM defines several high-level functional requirements that are pursued during the development of the model. SCORM authors call these requirements „ilities" and they are as follows [1]:

- Accessibility: The ability to locate and access instructional components from one remote location and deliver them to many other locations.
- Adaptability: The ability to tailor instruction to individual and organizational needs.
- Affordability: The ability to increase efficiency and productivity by reducing the time and costs involved in delivering instruction.
- Durability: The ability to withstand technology evolution and changes without costly redesign, reconfiguration or recoding.
- Interoperability: The ability to take instructional components developed in one location with one set of tools or platform and use them in another location with a different set of tools or platform.
- Reusability: The flexibility to incorporate instructional components in multiple applications and contexts.

A certain paradigm followed in SCORM is „the Web-based assumption“, according to which the Web provides the best means for access and use of the e-learning content.

3. IALMSM Overview

The Individually Adaptive Learning Management System Model (IALMSM) aims at realizing a generalized and yet tangible and concise model for individualized and adapted e-learning approach towards the e-learner. The behavior of the LMS adapts to the behavior of the educated individual, targeting to achieve the assigned results in the used e-learning strategy. The basic structure of the model, the subsystems and the information flow is shown on *figure 1*. The system behavior adaptation takes place in the Adaptive Subsystem (AS) of IALMSM. Individualization is required in order to attain adaptation. The system individualization is performed by the Individualizing Subsystem (IS) of the model. IS is responsible for the creation and population of an individual profile for each learner. To enable LMS to follow the learner's behavior, a system is needed for tracking events that carry characteristic information. This system is called Tracking Subsystem (TS) of IALMSM. Finally, to let the user communicate with the system, an auxiliary interface unit is required.

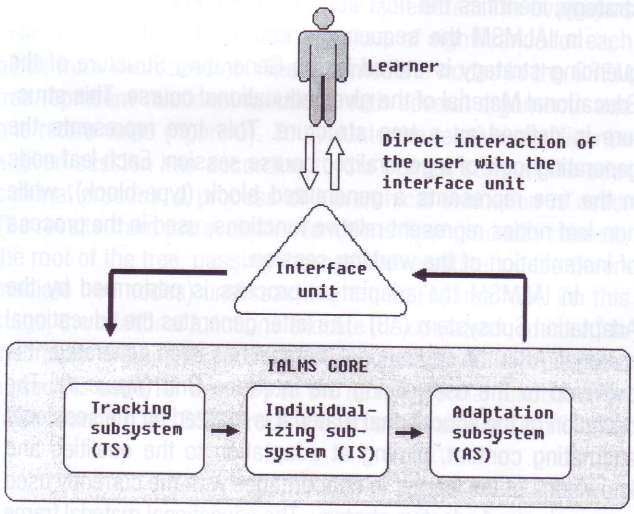

Figure 1. IALMSM basic structure

The information sent to the educated and received back from them, is called educational material. In the sense of IALMSM this concept is more general than its standard use. The educational material consists of sessions. A session is composed of educational blocks. Blocks are passive and active. Being an information stream between the educated and the system, the educational material should carry two-way information: from system to the learner (outgoing information) and from the learner to system (incoming information). All blocks may convey outgoing information, but only a part of them may convey incoming information. The latter are called active blocks, and the rest - passive blocks.

The information stream in IALMSM is developed on one hand between the system and the learner, and on the other - among the different subsystems.

IALMSM follows the user interface paradigm of „the Web-based assumption“. The authors believe that the Web provides the best means for access and use of the e-learning content.

4. Comparison of Individually Adaptive Key Aspects

The comparison between SCORM and IALMSM is conducted according to several key points of the model definitions that identify the major characteristics of the individually adaptive aspect of the investigated models.

Both models offer adaptive behavior towards the learner based on individualization of the educational process.

4.1. Block-based Content Delivery Paradigm

It is clear that the adaptation of the educational material has to be a dynamic process that develops in the course of education and interaction of the learner with the system. Most generally, such an adaptation would resemble a relevant and appropriate deviation of the educational material that is taking place during the educational process. Constructing the educational material according to a widely diverse model would yield to an excessively complicated procedure of authoring of the educational material and all accompanying individually adaptive strategies. A need of a block structure that is to be used in the process of educational material definition and structuring becomes apparent.

In SCORM the content is comprised of reusable content objects aggregated to form meaningful units of instruction [2]. One content object is delivered to the educated in a given moment. After completion of work recalculation is performed and the next step in the sequencing strategy is taken by delivering the next speculated content object (block of educational material) to the learner [4]. SCORM content objects do not set the logic of content object delivery. The objects are uncombined with sequencing information and rules in order not to limit reusability. Instead, externally defined sequencing rules are used allowing the developer of the instructional content to specify sequencing behavior separate from the instructional content. The sequencing information is organized and stored in a specific information structure.

On the other hand, IALMSM defines sessions as the delivery steps of the sequencing process. A session can be thought of as a lesson or a lecture in the traditional education. A session consists of aggregated blocks according to the Generating Structure of the Educational Material (GSEM) [5]. Instead of delivering one block of instruction at a time, IALMSM serves a group of blocks and lets the user overview and evaluate the whole session and then work on different blocks that comprise it or quickly reference other blocks of the working session backwards or forwards similar to the process of traditional learning. This approach assures a wide view and structured bearing towards the educational material. A session in IALMSM is constructed using generalized blocks of educational material called type-blocks that are instantiated in the course of educational material generation process for the current session of the educational course. The instantiation process follows the sequencing rules and strategy, formalized and stored in the Generating Structure of the Educational Material, external to the type-blocks.

In both models different levels of block granularity may be used. Low granularity would prevent the reusability of the blocks in SCORM and flexibility in session generation in IALMSM, while very high granularity would lead to fractioning and consequent incomprehensiveness of the generated educational material.

4.2. Organization of the Sequencing Information and Educational Content Adaptation and Delivery

SCORM uses a tree structure to describe the hierarchical relationship of the learning process (see *figure 2*). The information structure is called Activity Tree and describes an organization of learning activities. The Activity Tree structure allows the SCORM sequencing and navigation model to formalize the sequencing algorithms and behaviors in an implementation independent approach. The Activity Tree starts with its root (activity A). There are two types of nodes in the Activity Tree: clusters and leafs. SCORM allows the dynamic modification of the Activity Tree.

The root in the Activity Tree on *figure 2* is a cluster. A cluster is a node in the Activity Tree and also a learning activity that has descendent sub-nodes (sub-activities). The children nodes of a cluster node are either leaf activities (leaf nodes) or other clusters. A leaf activity has no descendents and is not a cluster. The cluster is the basic building block of the Activity Tree and most elements of the Sequencing Definition Model (SDM) of SCORM apply specifically to clusters. The parent activity in a cluster stores the sequencing strategy of the cluster. The leaf activities that are descendents of a cluster have attached content objects, that will be delivered to the learner according to the implemented sequencing strategy.

A SCORM based learning management system will choose learning activities for presentation in a sequence, defined at runtime according to the learner progress in the learning activities experienced so far, the learner own decisions and the sequencing strategy, stored for the current educational course. The learner works on a content object in context of a leaf learning activity. When an attempt begins on a leaf learning activity, its associated content object will be launched for the learner, and both a learner attempt and a learner session will begin for that content object.

SCORM learning activities are characterized with the following properties:

- They have a discrete start and finish.
- They have well-defined completion conditions.
- They can consist of sub-activities, nested to any depth.

The attempts of the learner to complete a given learning activity are always realized within the context of attempts on their parent activity (activities). A key point in the SCORM sequencing approach is that for a given Activity Tree one, and only one leaf activity can be attempted at any given time and all attempts on all of the leaf activity's ancestors (upwards to the root) will be in progress while the leaf activity is being attempted. When a leaf

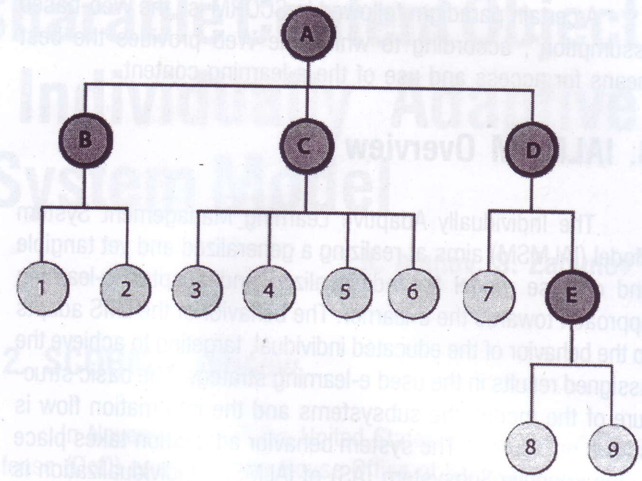

Figure 2. Sample Activity Tree in SCORM

activity is being attempted, the activity's corresponding content object will been launched. The process of the activity attempt starts with the activity identification for delivery. After the end of the work on the currently attempted activity, the attempt terminates and the LMS, according to the implemented sequencing strategy, identifies the next activity for delivery.

In IALMSM the sequencing information holding the sequencing strategy is stored in the Generating Structure of the Educational Material of the given educational course. This structure is defined as a tree structure. This tree represents the generating logic of a generalized course session. Each leaf node in the tree represents a generalized block (type-block), while non-leaf nodes represent relative functions, used in the process of instantiation of the working session.

In IALMSM the adaptation process is performed by the Adaptation Subsystem (AS). The latter generates the educational material. After the educational material has been generated, it is delivered to the user, using the Interface Unit (*figure 1*). The deviation of the educational material is realized by the session's alternating content, aiming at adaptation to the qualities and knowledge of the learner in concordance with the currently used sequencing and adaptive strategy. The educational material frame of a lesson specifies to what extent the session's content will vary. The certain degree of alternation is determined at the definition of the Educational Material Content (EMC) of IALMSM. Educational material content along with the Generating Structure of the Educational Material (GSEM) are the major informational units of the Adaptation Subsystem. EMC is fully programmable. It is defined for each session of the educational course. On the other hand, GSEM is defined only once for the whole course and it is invariable for all sessions. Each educational course that is used with the IALMSM presumes the definition of the Generating Structure of the Educational Material and the Educational Material Content. The educational process consists of session attempts. A session attempt is started once the learner begins working with the LMS, or finishes work on a given session and needs to continue their education. The IALMSM presumes the generation of a new session on three stages:

1. Selecting a new working session.
2. Instantiating the working session type-block content.
3. Type-blocks population.

The first two stages are carried out by GSEM, while the third is accomplished by EMC. The Educational material content consists of two types of components: generators and evaluators. These components are functions. For each type-block in GSEM there is a pair of defined functions - one generator function and one evaluator function. The generator is a function, that instantiates the given type-block by generating its educational material for the current working session. The evaluator function returns a relative value for the importance of the given type-block of the given session as per the current state of the learner attempting the session. The GSEM tree consists of a root node with no ancestors and one or more descendants, intermediate nodes with one ancestor and one or more descendants and leaf nodes with one ancestor and no descendants. To each leaf there is a corresponding type-block. GSEM represents a generalized structure of all sessions of the educational course. The type-block is an informational unit that conforms to a certain type of block from the educational material.

At the first stage of educational content generation and sequencing (Selecting a new working session) the relative significance of each session of the educational course is evaluated. The one with the highest significance is selected. The evaluators in the GSEM leaves determine the values of significance for each block from each session. The intermediate nodes in the GSEM tree represent relational functions with several arguments and one return value (*figure 3*). To evaluate the relative significance a given session has according to the current state of the educational process, a process of hierarchical evaluation is used. The results from the evaluator functions flow gradually towards the root of the tree, passing through the relational nodes (intermediate tree nodes) until reaching the GSEM tree root. On this stage, the relational functions execute the operation „addition" to their input arguments thus summing operation is executed and a result is used for an entry to the next relational function. The value reaching the GSEM root is used as a value of significance

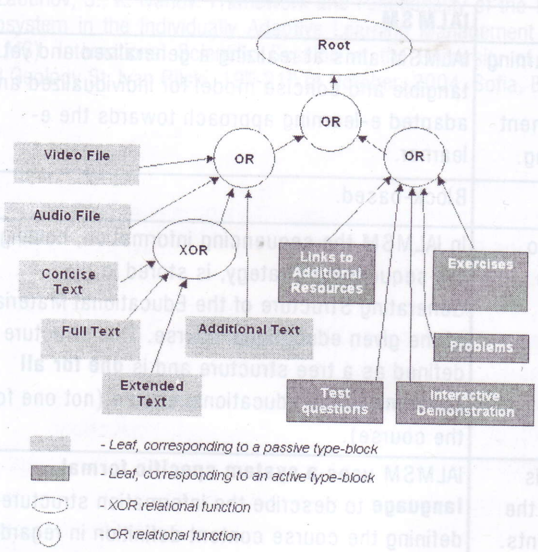

Figure 3. Sample GSEM Tree in IALMSM

for the need of assumption of the given session. The session with the highest significance value is selected for the next attempt.

During the second stage of the session generation (Instantiating the working session type-block content) the Adaptation Subsystem has already determined the session that is to be attempted by the learner. The goal of this stage is to define its content. This problem is generalized to specifying the subset of type-blocks that will comprise the current session variant. Again, the GSEM is used for this purpose. The significance value of each type-block is calculated using the evaluator functions in the GSEM leaf nodes. These values travel towards the root of the tree, passing through the relational functions (intermediate tree nodes). At this stage of processing, the relational functions perform their major purpose. There are two available types of relational functions: OR-type and XOR-type. When passing through a relational node of type OR, all type-blocks whose leaves have generated evaluation values greater than, or equal to the required threshold value are being combined and passed through. This threshold value is an attribute of the relational node. When passing through a relational node of type XOR, the type-block whose leaf has generated the greatest evaluation value is determined and if this evaluation value is greater than or equal to the required threshold value, the type-block is let to pass through the relational node. Again, the threshold value is stored in an attribute of the relational node. Eventually, there will be a subset of all leaf nodes (type-blocks of the generalized session) reaching the GSEM's root node. This subset represents all type-blocks that are to be aggregated in the current variant of the attempted session.

At the third stage of the new session generation (Type-blocks population) each type-block from the aggregated subset of type-blocks corresponding to the current session variant is instantiated. This instantiation is carried out by executing the corresponding generator function of the given type-block. The result is then merged and represents the educational material instance for the currently attempted session. Then, this session is delivered to the learner.

4.3. Learner to System Feedback and Individualization as a Precursor for Adaptation

SCORM Sequencing procedure is based on two different types of content - communicative and non-communicative content. Communicative content may pass information about the learner's activity through the SCORM Run-Time Environment Application Programming Interface (RTE API) [3]. Sharable Content Objects (SCOs) are responsible for following the learner progress. Instead of making assumptions about learner progress information that is not communicated, the LMS automatically assumes learner progress information based on defined default values and behaviors. Learning objectives are separate from learning activities. SCORM does not define how the learning objectives are associated with the learning activities. The tracking behavior is maintained as a set of objective status information. It controls the objective satisfaction status and objective satisfaction measure for each learning objective associated with a given learning activity. An activity may have one or more objectives associated with it.

In IALMSM, there are also two categories of type-blocks: active and passive. On the example on *figure 3* the active type-blocks have darker background. The instances of the active type-blocks may convey either feedback (tracking) information from the learner to the system and/or outgoing information from the system to the learner. The passive type-block instances may convey only outgoing information. In this manner the two models follow a similar approach. The tracking process of the learner activities takes place in the Tracking Subsystem (TS) of IALMSM (*figure 1*). Only active blocks are reaching the TS. Each active block is processed in the TS by an appropriate interpretation function [7], and the characteristic information from the active type-block is extracted. Characteristic information is stored by the IS in the form of attribute values. A certain attribute corresponds to a certain characteristic of the educated. Quantity levels, expressed by floating point numbers, relatively calculate learner's characteristics.

4.4. Use of Formal Languages in Content and Sequencing Definition Models

The Extensible Markup Language (XML) is used in SCORM to define the instances of the Content Organization and its sub-components. Also, the Sequencing rules are coded using XML. IALMSM uses a system specific formal language to describe the information structure defining the course content definition in regard to GSEM [6]. Using XML has a number of benefits such as the utilization of a well-known and widespread descriptive markup language. On the other hand, implementing a given model over an existing formal language implicates the language definitions to be conformed and confines the implementation according to the used language rules, structure and definition. In order to realize the task of definition of learning content and sequencing information IALMSM employs a system specific formal language thus avoiding the disadvantages pointed above. At the same time the IALMSM formal language realizes the full flexibility of the GSEM definition model at the lowest formalization cost.

5. Practical Realization and Implementations of the Individually Adaptive Aspects of the Two Models

After a discussion with specialists from ADL, they have reported that SCORM 2004 sequencing enables advanced branching strategies. For example, one piece of example content (produced by the Boeing Corporation), shows instruction of individual competencies followed by assessment of a joint application. Through the assessment, a learner may show they are not able to (experientially) apply a combination of individual competencies, thus receiving focused remediation on areas that need improvement.

Other SCORM 2004 courses have been developed that follow a more traditional adaptive instruction/assessment model. An assessment is provided that becomes increasing more difficult/complex as the learner continues to show mastery. At some point, the learner's 'true' knowledge/skill level is determined (in relation to the learning objectives) and further instruction is focused at that level of understanding.

IALMSM, on the other hand, has been implemented in an experimental LMS at the University of Mining and Geology - Sofia. An individually adaptive learning strategy has been realized that relied on knowledge assessment of the learner and adaptation of the learning material through delivery of content with varying level of complexity and/or exhaustiveness. The results showed short space of time needed for the learning strategies implementation due to the simpler adaptive model and the utilization of the specialized formal language for definition of the GSEM in IALMSM. It should be noted that IALMSM is designed especially towards individualization and adaptation, while SCORM is a broader model encompassing the adaptive and individualizing approaches.

6. A Structured Summary Providing a Concise Comparison between the two Models in their Major Points

	SCORM	IALMSM
Target	SCORM targets the creation of reusable learning content consisting of instructional objects delivered in a technical framework environment for Web-based and computer-based tutoring.	IALMSM aims at realizing a generalized and yet tangible and concise model for individualized and adapted e-learning approach towards the e-learner.
Content Delivery Paradigm	Block-based.	Block-based.
Organization of the sequencing information	SCORM uses a tree information structure to describe the hierarchical relationship of the learning process called Activity Tree. This structure is **one for the whole educational course**.	In IALMSM the sequencing information, holding the sequencing strategy, is stored in the Generating Structure of the Educational Material of the given educational course. This structure is defined as a tree structure and is **one for all sessions** of the educational course (not one for the course).
Use of Formal Languages in Content and Sequencing Definition Models	**The Extensible Markup Language (XML)** is used in SCORM to define the instances of the Content Organization and its sub-components. Also, the Sequencing rules are coded using XML.	IALMSM uses **a system specific formal language** to describe the information structure defining the course content definition in regard to GSEM.

Conclusion

The SCORM Content Aggregation Model and the Sequencing Model are diverse and broadly defined, being highly generalized and flexible, complex and rich in definitions and parameters. Thus SCORM allows the presentation and implementation of a broad variety of educational content structures and strategies. IALMSM offers still highly generalized model for sequencing but has simpler approach to the sequencing realization although based on the same block structure paradigm. IALMSM exhibits fewer formal terms and parameters, thus being easier to process with, and construct learning structures and sequencing rules. IALMSM offers the session attempt approach in contrast to learning activity attempt approach implemented in SCORM. The use of a system specific formal language tries to examine the concept of a direct and specific formalization of the learning content and adaptive behavior strategies, aiming at higher level of language simplicity and specificity.

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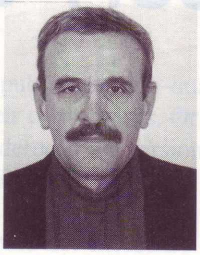

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