SCORM Sequencing and Navigation Model

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Abstract. One of the characteristics of e-learning is that students can acquire knowledge in different ways or with different learning paths, also called sequencing models. These sequencing patterns can be predefined by an expert from the type of learner or may be adaptive to the specific situation of each student. This paper analyzes the SCORM sequencing and navigation model for the dynamic presentation of learning content.

Keywords: Adaptive learning, learning objects, sequencing model, SCORM.

1 Introduction

The use of E-learning platforms and Learning Management Systems (LMS), and the design of online courses with their own educational technologies have increased significantly in education and business training. Learning Objects combined with LMS have been used to express knowledge, provide information and guide learning activities in the materials. The activity of an instructor or tutor is essential in guided learning: It is the tutor who selects the problems to show the learner, determines how to analyze the responses, presents the solution of certain problems, or decides to show some examples. The tutor also manages the training materials and is responsible for selecting the most appropriate material depending on the reported situation.

All of the above can be incorporated into a model similar to the offered by the Sharable Content Object Reference Model (SCORM) to display the material in an optimal structure determined by the instructor. SCORM is the most widely standard used for the development of E-learning courses. This standard is made up of independent units of information residing in a repository and viewable on any SCORM compatible LMS platform [1].

SCORM helps to define the technical basis for an online learning environment. This model has a Sequencing and Navigation structure for dynamic presentation of learning content based on the learner's needs. SCORM sequencing provides developers with E-learning courses with necessary tools to create complex designs that can even be adapted to individual learning needs of students, consistently applying sequencing capabilities that offer the following models [2]:

– Tracking Model,

– Activity State Model,
– Sequencing Definition Model,
– Navigation Model.

The SCORM Sequencing and Navigation structure is based on a version of the IMS Simple Sequencing, which defines a method to represent the expected behavior of a learning experience so that any LMS can generate the sequence of learning activities in a consistently manner [3]. In early versions of SCORM, the development of advanced online instructional courses was limited by several factors:

1. Sequencing Code embedded in the code of Learning Objects (LO);
2. Sequencing Behaviors inconsistent across Delivery Systems;
3. Sequencing Owners and Idiosyncratic Models; and
4. Sequencing Models and Activities ill-defined.

For many developers, the sophisticated intelligence structure of the course (for example, using diagnostic tests to derive individual routes or determine requirements for remedial instruction of each learner), is hard-coded in the LO. This technique limited the reusability, sharability and interoperability of SCORM-based training [4].

SCORM version 1.3 has largely solved the above-mentioned problems, and the Advanced Distributed Learning Community (ADL) has been given the task of developing and testing instructional content in accordance with the principles of Intelligent Tutoring Systems (ITS's) where developers can create instruction using more complex branching and sequencing [5].

This paper presents the characteristics of the sequencing and navigation structure of the SCORM model in order to analyze adaptive learning and the dynamic presentation of learning content.

2 Tracking Model

The values of this model are used for tracking or monitoring the sequencing control behavior. For each attempt on activity by a learner, that activity shall have associated tracking status data. Learner's interactions with a content object may affect the tracking data of the activity to which the content object is associated. Tracking data is used during the different sequencing processes to affect their behavior as follows (see Fig. 1):

– Communicative and Non-communicative content: The communicative content may transmit information about the learner’s interactions with the content through the SCORM Run-Time Environment Application Programming Interface (API), while non-communicative content does not use it.
– Suspending and Resuming Activities: An attempt on an activity may be suspended and later resumed. Resuming a suspended activity does not count as a new attempt and you can also try other activities while this is suspended, and there can be more than one activity suspended at any given time. Suspending the attempt on the root activity of the activity tree causes the

LMS to remember the last activity experienced by the learner in the activity tree and end the sequencing session in a suspended state. The learner may later resume the attempt on the root of the activity tree and at that time, it is will also resume the last activity performed by the student.

– Persistence of data: It is not specify how the data will persist between a beginner's multiple sequencing sessions and a the activities of an particular tree, including, for example, if there are different learning experiences or multiple entries from the same activity. One attempt of this type can comprise one or more sequencing sessions. LMS policies should govern whether such information will be retained after this session.

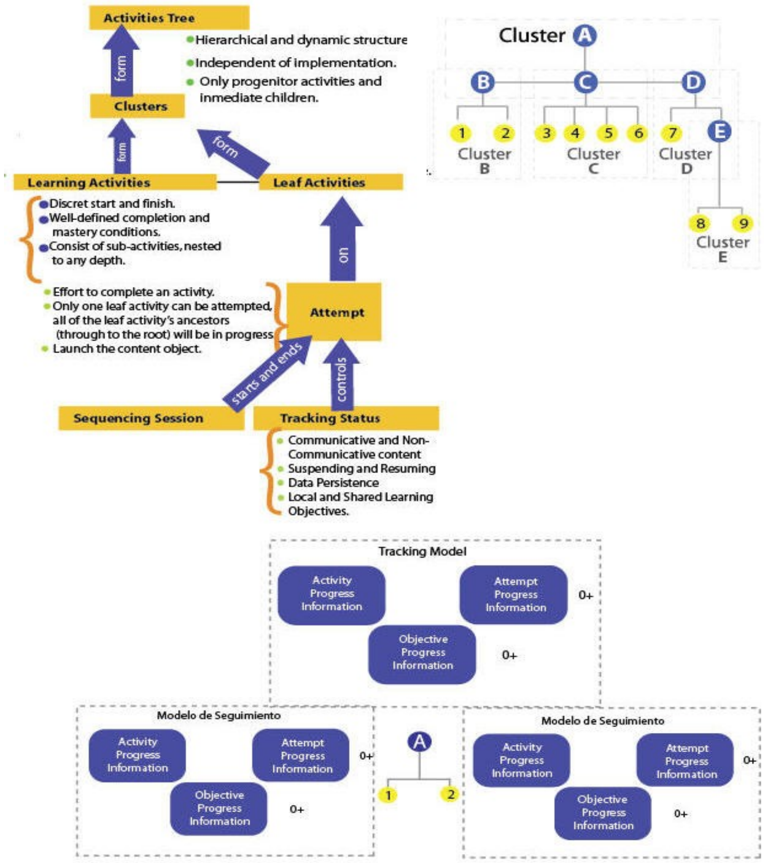

Fig. 1 Tracking Model

– Learning Objectives: Learning Objectives are separate from learning activities. SCORM does not impose any restriction on how learning objectives are associated with learning activities nor does it define how content objects are to use learning objectives. The SCORM Sequencing Behaviors make no assumption as to how to interpret learning objectives (e.g., is it a capacity domain, or is it a shared value, etc.). From a tracking perspective, a set of objective status information (objective satisfaction status and objective satisfaction measure) is maintained for each learning objective associated with a learning activity. Activities may have more than one target associated with them.

The tracking control status attempts in a learning activity. An attempt is defined as an effort to complete an activity, and during that effort, zero or more learning objectives may become satisfied. Attempts on activities always occur within the context of attempts on their parent activity(ies). It is noteworthy to mention 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 (through the root) will be in progress while the leaf activity is being attempted. When a leaf activity is being attempted, it can be assumed that the activity's corresponding content object has been launched.

An attempt begins when the activity is identified for delivery and ends while the LMS's sequencing implementation attempts to identify the next activity for delivery. An attempt on an activity is closely related to learner attempt on the activity's associated content object. A sequencing session is the period between the time learners begin the attempt on a tree root activity of activities and the time that such attempt ends, outside the context of the sequencing session, it is considered that the current activity is undefined.

A learning activity can be described as a useful unit of instruction; it is conceptually something the learner does while progressing through the instruction. A learning activity may provide a learning resource to the learner or it may be composed of several sub-activities. A cluster includes a single parent activity and its immediate children, but not the descendants of its children.

Finally an activity tree is a general term that represents an instance of hierarchical learning activities and the corresponding sequencing information for the interoperable application of specified sequencing behavior. Because the SCORM Sequencing Behaviors are defined in terms of structured learning activities, a functional content structure provides the necessary starting point for deriving an activity tree. In terms of sequencing, a content organization represents an interoperable structure of an activity tree. The content organization (<organization> element) is the root of the activity tree and each of its <item> elements correspond to a learning activity, depending on the granularity.

3 Activity State Model

This model manages sequencing state of each activity in the Activity Tree and the global state of the Activity Tree. This is a dynamic run-time data model utilized by the LMS's sequencing implementation to manage the state of the activity tree during a sequencing session. The overall sequencing process uses the following sequencing behavior (see Fig. 2):

- Navigation Behavior: Describes how a navigation request is validated and translated into requests for completion and sequencing.

- Termination Behavior: Describes how the current attempt on an activity ends, how the state of the activity tree is updated and if some action should be performed due to the attempt ending.
- Roll up Behavior: Describes how tracking information for cluster activities is derived from the tracking information of its child activities.
- Selection and Randomization Behavior: Describes how the activities in a cluster should be considered during processing a sequencing request.
- Sequencing Behavior: Describes how a sequencing request is processed on an activity tree in attempt to identify the next activity to deliver.
- Delivery Behavior: Describes how an activity identified for delivery is validated for delivery and how an LMS should handle delivery of a validated activity.

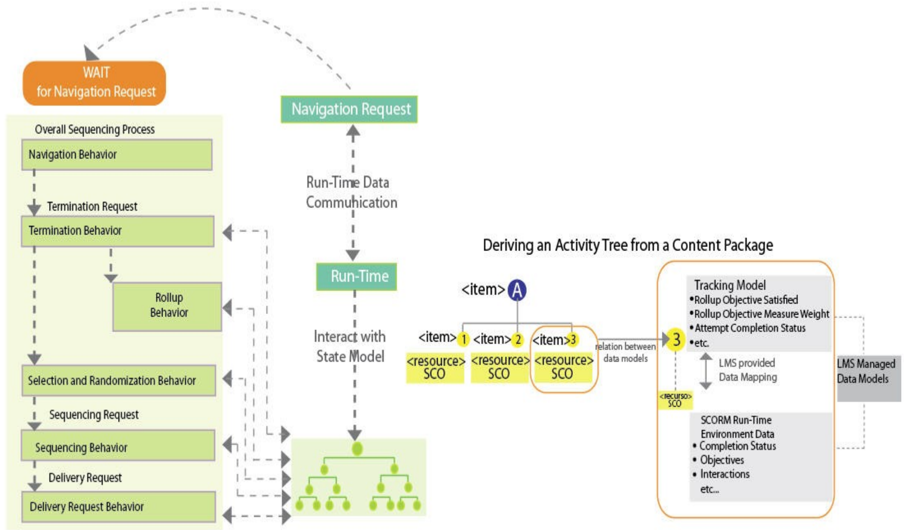

Fig. 2 Activity State Model

4 Sequencing Definition Model

This model defines a set of elements that may be used by content developers to define intended sequencing behavior. The definition model elements are applied to learning activities within the context of an activity tree (see Fig. 3). Each element has a default value that is to be assumed by any sequencing implementation in the absence of an explicitly defined value. SCORM does not require or imply that the values of sequencing definition model elements apply to an activity are, become or remain static for any period. The LMS may alter the element’s value as you like, however, some groups of sequencing definition model elements are highly coupled to one another through the SCORM Sequencing Behavior.

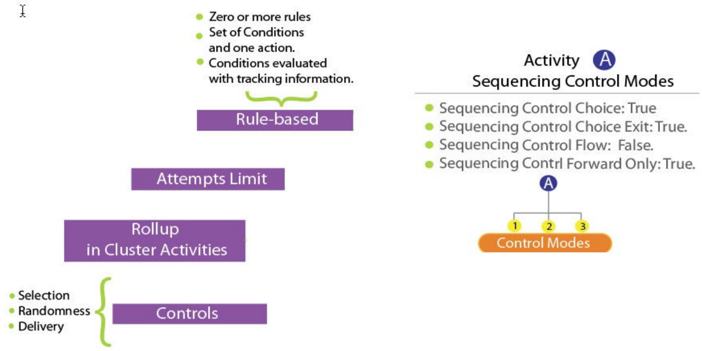

Fig. 3 Sequencing Definition Model

The Sequencing Control Modes allow the content developer to affect how navigation requests are applied to a cluster and how the cluster's activities are considered while processing sequencing requests. Sequencing Control Modes may be applied, as needed, to constrain a desired learning experience. Control option restriction defines a set of controls of restricted options to impose greater conditions and behaviors regarding the manner in which applications are processed by sequencing.

SCORM sequencing employs a ruled-based sequencing model. A set of zero or more sequencing rules can be applied to an activity and the rules are evaluated at specified times during various sequencing behaviors. Each sequencing rule consists of a set of conditions and a corresponding action. The conditions are evaluated using tracking information associated with the activity. The behavior associated with the rule's action is performed if the rule's condition set evaluates to True. The structure of a sequencing rule is (if [condition] then [action]).

A content developer can define limit conditions that describe conditions under which an activity is not allowed to be delivered. Limit conditions can be associated with activities and are conditional based on activity's tracking status information. When a limit condition is met or exceeded, the activity becomes unavailable for delivery. SCORM only requires the support for the Limit Condition Attempt Limit element. Attempt limit does not require the evaluation of any time-based limit conditions. Therefore LMS's are not required to manage data for or honor the evaluation of any of the optional portions of the Limit Conditions Check Process.

Cluster activities are not associated with content objects, therefore is no direct way for learner progress information to be applied to a cluster activity. SCORM sequencing provides a way to define how learner progress for cluster activities is to be evaluated. A set of zero or more Rollup Rules may be applied to a cluster activity and the rules are evaluated during the Overall Rollup Process. Each Rollup Rule consist of a set of child activities to consider, a set of conditions evaluated against the tracking information of the included child activities, and a corresponding action that sets the cluster's tracking status information if all conditions evaluates to True. Rollup Rules have no effect when defined on a leaf activity.

There is a mechanism for learning objectives associated with an activity. An activity may have one or more learning objectives associated with it. SCORM does not describe how a learning objective is defined, used or read, but for sequencing purposes, each learning objective associated with an activity, have a set of tracking status information that allows student progress towards the learning objective, thus enabling conditional sequencing decisions.

There are randomization controls that describe when and what actions will the LMS take to reorder the available children of encountered cluster activities, while performing the various sequencing behaviors. Content developers may apply randomization controls to any cluster in the activity tree.

There are delivery controls describing actions that LMS will take prior to an attempt on an activity beginning and after the attempt ends. Delivery controls shall be used by LMS's to aid in the management of the activity's tracking status information. The elements also indicate whether the LMS can expect the SCO associated with the activity to communicate specific types of tracking information.

5 Navigation Model

The SCORM Navigation Model considers the use of the following concepts or processes:

- Start Navigation Requests. The navigation model only applies to SCORM navigation between learning activities. SCORM currently does not directly address the ability to define the sequencing or navigation within a Sharable Content Object (SCO). However, SCORM does not preclude the ability to navigate between SCO's (this ability is completely controlled by the SCO).
- The SCORM Navigation Model defines a set of navigation events that can be triggered by a student through an LMS and content provided user interface devices or directly by SCO's. SCORM does not define how these events are activated within a SCO or through the LMS. Navigation requests are processed as defined by SCORM Sequencing Behaviors. They provide the learner and content an interoperable means to indicate how the progress through an activity tree is; such as to choose a particular learning activity, continue to the next activity or go back to a previous activity.
  - Processing Navigation Requests. When the learner or content triggers a navigation event through any mechanism, the LMS processes the corresponding navigation request by invoking the sequencing system: The result of processing the navigation request will always be one of the following:
  - If the effect of the navigation request is to end the current attempt on the activity tree, the LMS will process an Exit All navigation request, which ends the attempt and returns control to the LMS.
- After evaluating the current tracking status and the applicable sequencing information on the activity tree, the LMS determines that processing the intended navigation request should not be honored. In that case, the LMS ignores the navigation request. The LMS takes no sequencing action until another navigation request is triggered.
- Completion of Content Objects by Navigation Means.

– From this description it is noted that if a LMS offers user interface devices for navigation events, the learner may indicate their willingness to navigate by triggering one or more of these devices. When learners indicate their desire to navigate, SCORM assumes the learner is implying he just ended with the currently launched content object, if any. If the chosen LMS navigation attends the event initiated by the learner, you must first remove (download) the content object released at that time and then process the request for proper navigation. The content object must be removed before processing the navigation request to ensure that the content object has recorded information on learner progress that may affect sequencing.

The SCO's intentions can communicate directly to LMS through the SCORM Navigation Data Model. A SCO must also indicate to the LMS should act on its intentions; this is done by invoking that the method is complete, which indicates that the SCO has completed communication with the LMS. Therefore, if the SCO has completed communication and indicated a navigation intention, the LMS system must respond. Once the request has finished processing, the LMS process any outstanding navigation event initiated by the learner. If there were no outstanding navigation events initiated by the student, the LMS will process the last navigation request sent by the SCO. If neither the student nor the SCO indicates their navigation intentions, the LMS should wait for the learner to indicate a navigation event.

6 Conclusions and Future Work

SCORM does not address, but does not exclude artificial intelligence-based sequencing schedule-based sequencing, sequencing requiring information from closed systems and external services, collaborative learning, customized learning, or synchronization between multiple parallel learning activities.

In this paper we presented the sequencing model and SCORM navigation; our hope is that this paper will serve as a useful tool in helping readers who are not yet experts in the field. It is considered that the SCORM Sequencing and Navigation Model is not enough to adapt Learning Objectives (LO's) Sequencing to each student's specific learning situation because it is a rule-based model where the instructor plays a key role to previously set different learning paths that learner may have. As it is also a deterministic model, it is based on the achievement of certain objectives to determine whether or not a student has been progressed. Then, it is proposed as future work, to present a more comprehensive model (not deterministic) aided by Artificial Intelligence tools managing uncertainty and could be used to add intelligence and adaptation to the already existing SCORM sequencing model.

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