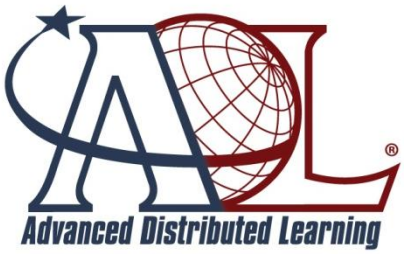
SCORM Users Guide for Programmers

Version 10

September 15, 2011



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Getting Started with SCORM

This purpose of this guide is to help the e-learning programmer become familiar with SCORM 2004. It is meant for programmers who have no experience with SCORM, or who are familiar with earlier versions of SCORM. It is not meant to be the definitive user's guide; there are other documents where all the technical information can be found (a link to the SCORM Books can be found under SCORM Documentation of this page).

If you are new to the Sharable Content Object Reference Model (SCORM) standards, or have only used a version prior to SCORM 2004, this section will help you acclimate to currently accepted SCORM development procedures. In the first part, we present a typical programmer approach to creating SCORM-conformant e-learning, and in the second part we walk you through setting up your first SCORM course.

1.1 Programmer Process

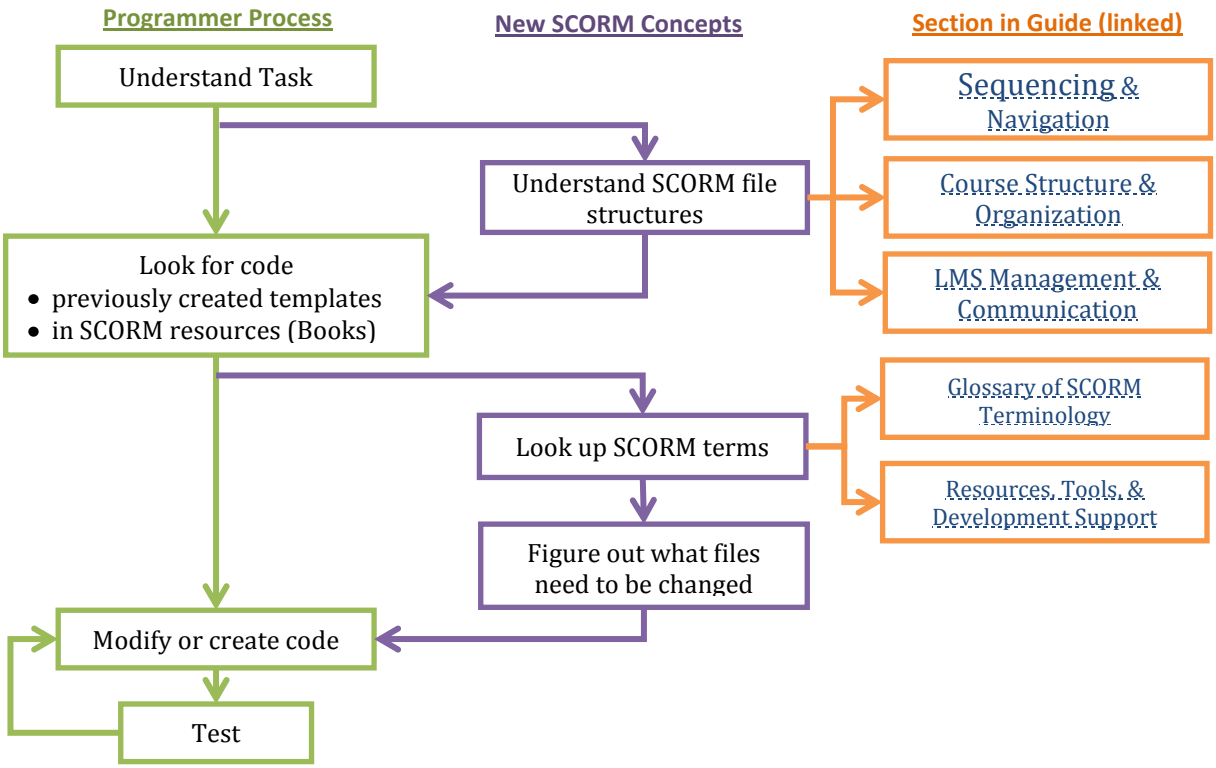


Figure 1.1 Programmer process for developing SCORM-conformant e-learning.

A typical programmer approach to navigating the SCORM waters and creating SCORM-conformant e-learning is outlined in Figure 1.1. For example, after understanding the instructional task that the instructional systems designer (ISD) has shared with you, it is important to understand how SCORM file structures can support the task. The sections that

will help you understand SCORM file structures (see Figure 1.1) are Sequencing & Navigation[1], Course Structure & Organization, and LMS Management & Communication.

You will also need to look up and understand new SCORM terms and get familiar with the resources available to you. This information can be found in the Glossary and the Resources, Tools, & Development Support sections, respectively.

1.2 Your First SCORM Course

The easiest and recommended way to create a SCORM content package is by using a template. A template is a conformant SCORM 2004 content package (zip file) consisting of a simple course structure with HTML files that can be modified and extended to create your course. It typically also includes a helper JavaScript file, sometimes called the API Wrapper, which makes using the SCORM API (see Understanding the SCORM API) easier for the programmer to use.

Templates are typically provided by the community and may implement instructional design patterns. For the purposes of this document we will use a simple starter template provided by ADL located (download from SCORM API/Code Example). The structure of the starter template is simple. It contains a single SCO followed by an aggregation of 2 SCOs (see Figure 1.2).

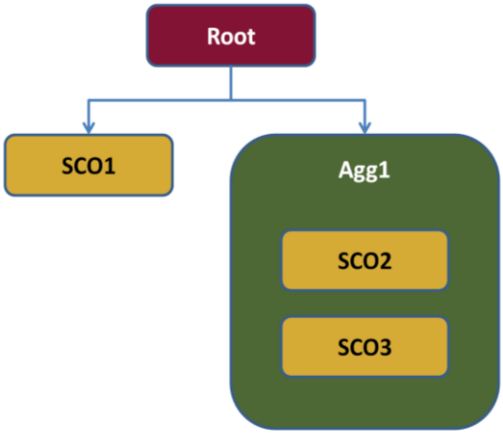


Figure 1.2 Structure of the starter XML template

Steps to using a template

1. Locate and download the template file (zip file).
2. Copy the .zip file to your project area and unzip.
3. Edit the HTML files of the template to add content.
4. Edit the imsmanifest.xml file: replacing titles, adding resources, etc.
5. If necessary, edit sequencing and extend the template according to the design.

[1] Blue dotted-underlined text are section names and contain hot links to those sections in this document.

Steps 1-4 of this process should be straightforward to a programmer familiar with web application development. Step 5 will be more challenging to those starting out in SCORM. Refer to the remainder of this document for information on how to implement sequencing and other advanced features of SCORM 2004.

1.3 SCORM Terms

Table 1.1 lists some SCORM terms as they relate to common ISD terms. These are useful to know in order to communicate well with instructional designers who will be designing the courses you implement. Some commonly used SCORM or ISD terms have official terms used in the SCORM Documentation Books that you should also be aware of.

Table 1.1 SCORM terms as they relate to ISD terms

COMMON ISD TERM	COMMON SCORM TERM	OFFICIAL SCORM TERM
Video, text file, image, or other media; also called asset	Asset	Asset; Also, a Resource is a group of assets
Learning object (LO)	Sharable Content Object (SCO)	SCO
Course **(set of learning objects)**	Organization; Or Content Package	Organization or Content Organization
(None)	Activity: a SCO or logical grouping or aggregation of SCOs, with associated sequencing; could refer to an Organizational Structure	Activity
Organizational Structure	An Activity Tree represents the data structure that an LMS implements to reflect the hierarchical, internal representation of the defined learning activities.	Activity Tree/ Organization
Course content **(all assets, LOs, branching, structure for a course)**	Content Package (a PIF or zip file that contains the course content)	Content Package
(None)	Content Aggregation represents the collection of content and its structure represented within a Content Package	Content Aggregation is a nested structure. A content package might have 1 or 100 aggregations.
Branching	Sequencing (not internal branching within a SCO)	Sequencing
Scoring	Objective (NOTE: this is not related to the ISD term Learning Objective)	Objective
Branching instructions to the programmer, flowcharts	Rollup and Sequencing rules (not internal branching within a SCO)	Rollup and Sequencing rules
Learner interactivity data (any interactions with content, usually used for assessment data)	Interactions	Interaction Data/ cmi.interactions (see the Assessments Cookbook section)

Course Structure & Organization

2. Introduction

This section addresses the most basic elements of a SCORM course. In its simplest definition, a SCORM 2004 course consists of web-deliverable assets bundled into a SCORM 2004 4th Edition Content Package (see CAM 3.1)[2]. This Content Package is a zip file which provides a standardized, interoperable way for you to exchange digital resources among different learning management systems (LMSs), content repositories, and operating systems.

2.1 Anatomy of a SCORM Course

Figure 2.1 depicts SCORM content components from smallest (assets) to largest (curricula); each component is described individually. The colors you see here for each component are used throughout this Guide to help you quickly identify the types of components. Assets are blue, sharable content objects (SCOs) are gold, aggregations are green, and organizations and root aggregations are red. Curricula are shown here in gray and red, but they may be comprised of other learning activities and are outside the scope of SCORM.

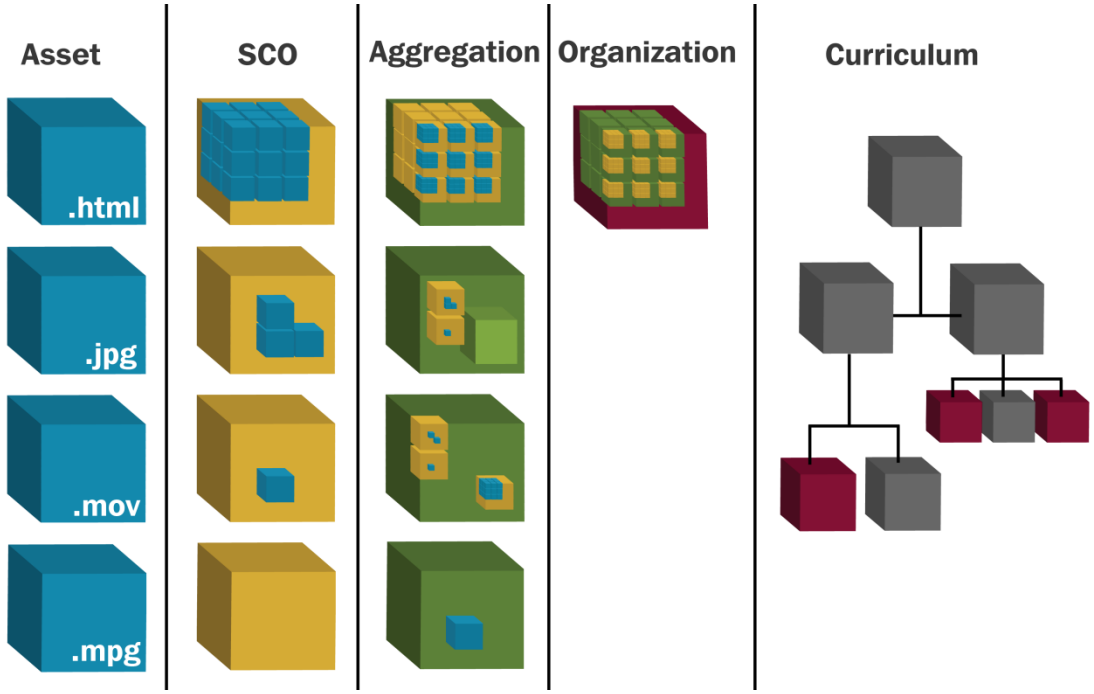


Figure 2.1 Components of SCORM Content

[2] The Content Aggregation Model is one of the SCORM "Books". The whole suite of books (CAM, SN, & RTE) is available for download under Documentation at http://www.adlnet.gov/capabilities/scorm#tab-learn.

2.2 Asset

Assets are electronic representations of media, text, images, sounds, HTML pages, assessment objects, and other pieces of data. They do not communicate with the LMS. Assets will likely be your most reusable items; they can be redeployed, rearranged, repurposed, or reused in many different contexts and applications. The figure to the left depicts each asset as a small blue box with examples of several asset types (such as .gif, .mpg, .html, .txt, .jpg).

For example, in Figure 2.2, an image of the Hazard Class 7 Radioactive placard could be used in training materials for different audiences in both commercial and DoD transportation as well as by different individuals such as truck drivers, first responders, and shipping inspectors who may be affected by the transportation of hazardous materials. The radioactive symbol could be reused as a "slice" (separate graphic file) which is seamlessly integrated into the top and bottom of each composite graphic.

Figure 2.2 Shared Asset Example

2.3 Sharable Content Object

SCOs are the smallest logical unit of information you can deliver to your learners via an LMS. The term SCO has different implications for instructional designers and programmers. Instructional Systems Designers (ISDs) and content authors view a SCO as content; they focus on the actual instructional material in the SCO. Programmers may view a SCO as a web application that communicates with an LMS.

In technical terms, a SCO is defined as the only component of the course that uses the SCORM Application Programming Interface (API) for communication with an LMS. The SCORM API is a standardized method for a SCO to communicate with the LMS when learners are interacting with a SCO. There is specific information the SCO can retrieve from the LMS and store in the LMS. For example, it can store values in the LMS, such as a score or completion status, or retrieve information from the LMS, such as a learner's name. Figure 2.3 depicts the API communication link between a SCO and an LMS.

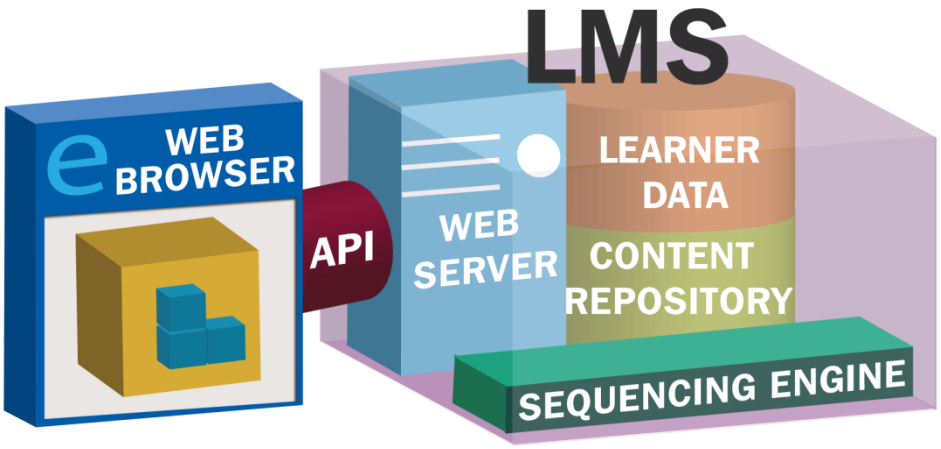
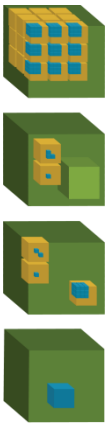


Figure 2.3 API Communication Link

Experienced SCORM designers talk about SCOs as the content that learners see and interact with, but this is not the complete story. Technically, a SCO must communicate with the LMS to be called a SCO (see Content Packages section).

2.4 Aggregation



An aggregation is a collection of related activities. An aggregation may contain SCOs or other aggregations. In this Guide, an aggregation is defined as a parent and its children.

Note: The SCORM documents refer to an aggregation as a cluster. The terms aggregation and cluster may be used interchangeably. In this document, we will use the term aggregation.

The figure to the left depicts aggregations as green boxes and SCOs as gold boxes containing blue assets. Aggregations are used to group related content so that it can be delivered to learners in the manner your ISD prescribes.

An aggregation is not a physical file; it is a structure within a SCORM manifest where sequencing rules are applied to a collection of related SCOs or aggregations.

Figure 2.4 depicts a SCORM aggregation called Hazard Classes that contains multiple aggregations: Hazard Class 1 Explosives; Hazard Class 2 Gases, and others. This structure would continue to reveal individual aggregations for all nine hazardous materials classes. These aggregations, the green boxes, do not contain content themselves, but are a way of structuring content to apply sequencing rules.

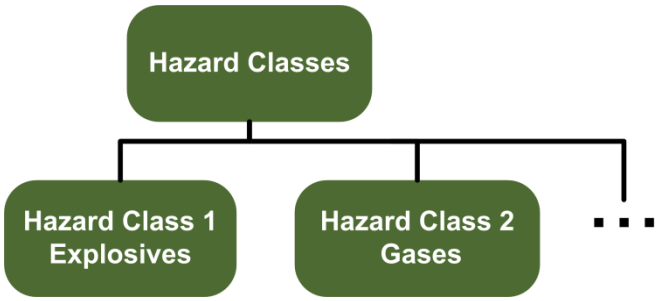


Figure 2.4 Example of Potential SCORM Content Aggregations

Figure 2.5 depicts the expansion of the Hazard Class 1 Explosives aggregation, the green box, with six SCOs, gold boxes: Hazard Class 1 Explosives Overview, Division 1.1 Mass Explosion Hazard, Division 1.2 Fragmentation Hazard, Division 1.3 Fire Hazard, Division 1.4 Minor Explosion Hazard, Division 1.5 Very Insensitive Explosion Hazard, and Division 1.6 Extremely Insensitive Explosion Hazard. (Refer to Sequencing to learn more about structuring content for sequencing).

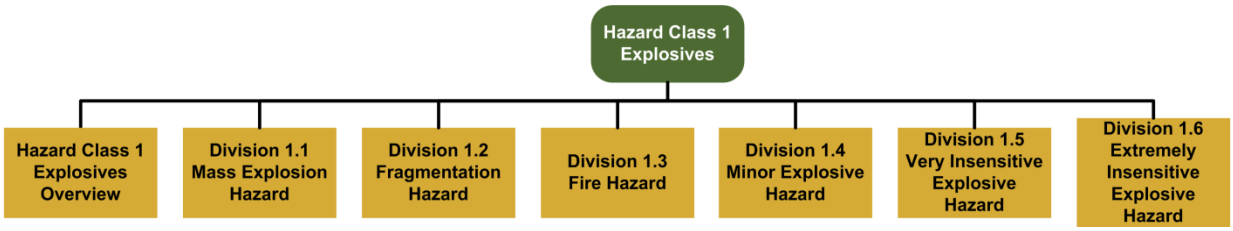
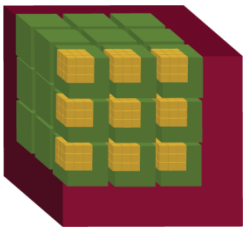


Figure 2.5 Example Expansion of a Potential SCORM Content Aggregation

2.5 Organization



The organization is the part of a content package where SCOs are ordered into a tree structure and sequencing behaviors are assigned to them. The figure to the left depicts an organization as a red box containing multiple green aggregations and gold SCOS. The organization outlines the entire structure you have created for the content that you intend to deliver as a single content package. Each organization is a top-level aggregation, also referred to as the root aggregation in this document.

Note: Originally, the content package was defined to allow for multiple *organizations*. However, this is currently not supported, so it is suggested that you only use one *organization* per content package.

Figure 2.6 depicts the organization called Types of Hazardous Materials (HazMat) using a red box at the top of the tree with rounded corners. The organization represents a content package containing three aggregations. The aggregations: Types of HazMat, Hazard Classes, and Transportation Documentation, are green boxes. The Types of HazMat and Hazard Classes aggregations also show their associated SCOs, the gold boxes, so you can see how organizations are structured.

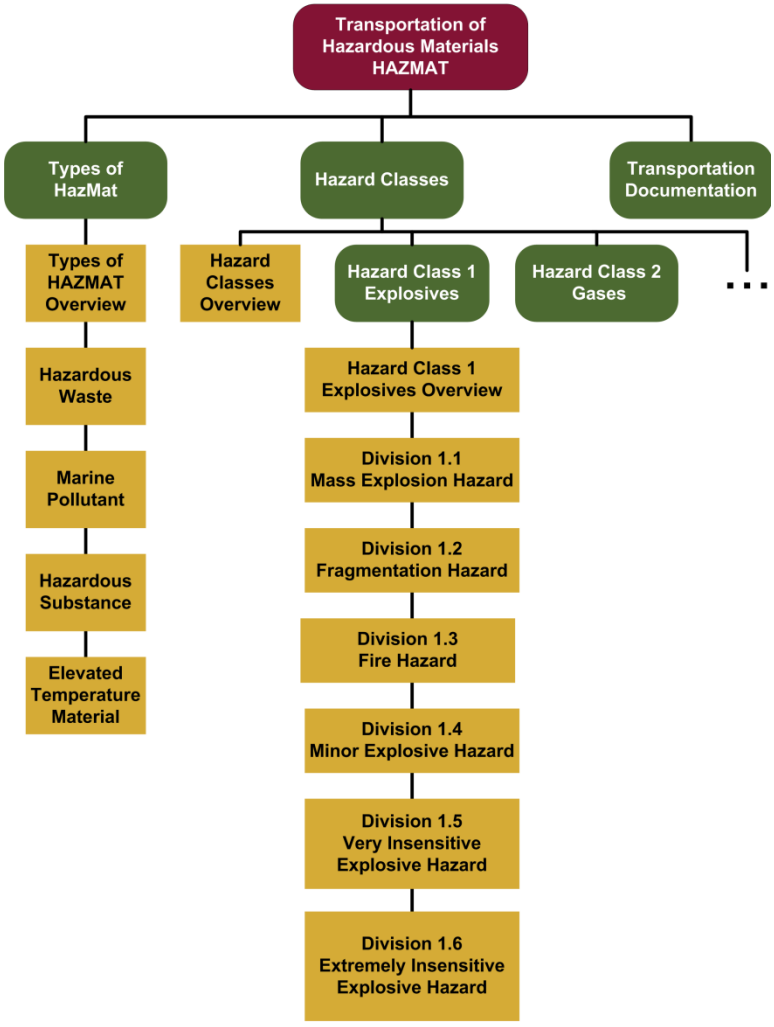
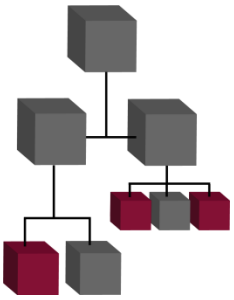


Figure 2.6 Example of Potential SCORM Organization

2.6 Curriculum or Course



While a curriculum or course is outside the scope of SCORM, SCORM-conformant content can be part of a curriculum or course that is managed by your LMS. The figure to the left depicts a curriculum consisting of multiple independent components. In this figure, the red boxes represent SCORM organizations while the gray boxes represent a combination of other learning experiences (such as, collaboration sessions, labs, lectures). A curriculum typically includes courses, lessons, and assessments using a variety of delivery media and instructional strategies.

The curriculum for a truck driver may include SCORM-conformant content organizations in loading, hazardous materials transportation, and road safety, as well as, actual driving or loading experiences on a test course and also on public roadways. The LMS would deliver

and store learners' performance data for the SCORM-conformant content organizations, and it might also store and manage the scheduling and completed work accomplished on the test course and public roadways.

3. Content Packages

3.1 Introduction

All SCORM content is ultimately placed in a "content package." The content package is a .zip file, sometimes called a Package Interchange File (PIF), that contains everything needed to deliver content to learners via a SCORM 2004 conformant (see Glossary of SCORM Terminology for a definition) LMS. As the programmer on your team, you are typically responsible for creating the SCORM content package.

There are tools available to create content packages or you may choose to create them from scratch. Some authoring tools will create the entire content package after you load your SCOs and assets into the tool. The ADL version of the RELOAD is an example of such a tool. RELOAD provides a graphical interface for creating a content package and managing sequencing and other values contained in the manifest file that is described below. Ensure that the tools you select match the knowledge, skill, and ability levels of the team members who will use them. This guide will not go into much detail on tools as there are many variations in functionality.

3.2 When to Implement

SCORM does not dictate how learning content is organized. A content package may consist of a single SCO or may be an organization of hundreds of SCOs. It really depends on the design and how the course will be used and shared across organizations. It's also important to understand how your target LMS organizes content. Most LMSs allow registrations at the content package level and many allow the creation of a curriculum by combining content packages.

3.3 How to Implement

3.3.1 Components of a Content Package

A SCORM content package contains two principal parts:

1. The XML manifest file that describes
   - All of the SCOs or assets you want to include in the package
   - A representation of the content structure diagram created (called the organization)
   - The sequencing rules
   - Metadata for the SCOs, aggregations, and the package itself
2. All of the actual SCO and asset files for the content package.

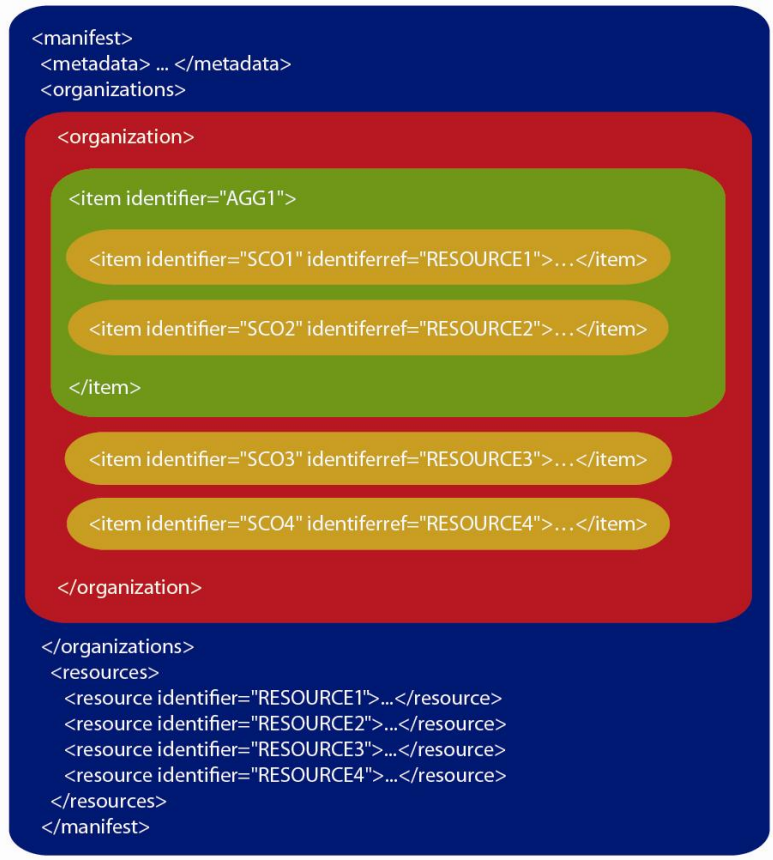
Manifest File

An Extensible Markup Language (XML) file called a manifest organizes the content package. The manifest is a detailed set of instructions, structured in a manner specified by SCORM, that organizes your content package and tells the LMS when, how, and what content to deliver to your learners.

An authoring tool typically creates the manifest, though some programmers prefer to create them from scratch using an XML editor. In this guide, we will not assume the use of authoring tools, so you can begin to understand all the components and how they fit together.

The manifest file is always named `imsmanifest.xml` and it always appears at the top level of a content package (zip file), regardless of the structure of the rest of the package.

The basic structure of a manifest file is as follows:



Metadata

The metadata section is where additional informative data about the course is placed. See CAM 4 or the section about the Content Aggregation Model (CAM) Book in this document,

for details of how this section is structured. At its simplest and most common form, it only contains the *schema* and *schemaVersion* elements:

```
<metadata>
    <schema>ADL SCORM</schema>
    <schemaversion>2004 4th Edition</schemaversion>
</metadata>
```

Note: The *schemaVersion* designates the SCORM version and many LMSs read this value to determine which SCORM engine to apply during the runtime of a course.

Additional metadata regarding the organization, activities, and assets in the course may be referenced in the manifest file. This metadata is typically provided to you by the ISD (see Glossary of SCORM Terminology). For further reading on how to reference metadata in the manifest file, see CAM 4.5 or the section that describes the Content Aggregation Model (CAM) Book in this document.

Organizations

The *organization* consists of multiple activities (SCO or aggregation) represented by *item* elements. This structured representation of the content is typically called the "Activity Tree." Inside the *organization* and *item* is where all the sequencing (see Sequencing & Navigation) is defined.

The XML structure of an organization is below.

```
<organizations default="ORG-SAMPLE">
    <organization identifier="ORG-SAMPLE"
                  adlseq:objectivesGlobalToSystem="false">

      <item identifier="AGGREGATION1">
        <title>Sample Aggregation</title>
        <item identifier="SCO1" identifierref="RES1">
          <title>Sample SCO</title>
        </item>
        <item identifier="SCO2" identifierref="RES2">
          <title>Another Sample SCO</title>
        </item>
      </item>

    </organization>
</organizations>
```

Resources

SCORM content typically consists of web-delivered assets. These assets may be HTML, images, Flash objects, audio, video, etc. All of these assets are listed in the *resources* section of the manifest file. A *resource* is a grouping of related assets. There are two types of resources: SCO resources and asset resources. This is designated by the *adlcp:scormType* attribute in a *resource*. A SCO resource contains the starting or "launch" point for a SCO along with a list of files and dependencies used by the SCO, while an asset resource

provides supporting materials which could also support other SCOs. The href attribute in the resource element is used to determine which file is initially delivered to the learner. If a set of assets is shared by multiple SCOs, then an asset resource listing may be created to remove repetition of assets in the manifest file. The asset resource is referenced using the *dependency* element. The following code shows a simple example of a manifest file having a resource for a SCO (SCO-RESOURCE) that has a dependency on another resource (LESSON-COMMON).

> **Best Practice**: An important attribute of the organization element is the `adlseq:objectivesGlobalToSystem`. This tells the LMS how to scope the global objectives in the course. Global objectives are programmer-specified variables stored on the LMS which can be read and written by a SCORM 2004 course (see section on Tracking across SCOs using Global Objectives). Typically, it is a best practice to contain them in the content package and therefore a value of "false" should be used. The default is "true," so it's important to explicitly define this.

```
<organizations>
    <organization>
         <title>Example Course</title>
         <item identifier="EXAMPLE-SCO" identifierref="SCO-RESOURCE">
              <title>Example SCO</title>
         </item>
    </organization>
</organizations>
<resources>
    <resource identifier="SCO-RESOURCE" adlcp:scormType="sco" type="webcontent"
                        href="load.html" >
       <file href="load.html" />
       <file href="example.jpg" />
       <file href="example.swf" />
       <file href="example.mp3" />
        <dependency identifierref="LESSON_COMMON" />
    </resource>
    <resource identifier="LESSON-COMMON" adlcp:scormType="asset"
                        type="webcontent" >
       <file href="common/apiwrapper.js" />
       <file href="common/common.js" />
       <file href="common/logo.jpg" />
    </resource>
</resources>
```

> **Best Practice**: Using dependencies is useful to reduce redundancy in the manifest file and keep it better organized.

3.3.2 Content

SCORM does not dictate the format of the content of a SCO. It is typically standard web content that can be delivered in a web browser.

API Wrapper

There are some required elements of this web content that make it a SCO. A SCO must find an instance of the SCORM. This is accomplished by including a special JavaScript file in the content's main HTML page. This JavaScript file is sometimes called the API Wrapper. It will be named differently depending on where you acquired this file. For the context of this document, we will reference it as APIWrapper.js. The functions referenced in this document will the ones provided in the APIWrapper.js file included in the starter template and in the Appendix (see SCORM 2004 API Wrapper).

The APIWrapper.js file will locate the SCORM API instance and contains all the functions required for the content to communicate with the LMS. These functions are standard JavaScript functions and may be used just like any other JavaScript functions in a web page. To be conformant, a SCO must make, at a minimum, two calls. The first, *doInitialize(),* must be called to initiate communication between the LMS and the SCO. The second, *doTerminate()*, must be called at some point before the SCO exits. The HTML of the simplest SCO might look like this:

```
<html>
  <head>
    <script type="text/javascript" src="APIWrapper.js">
    <script type="text/javascript">
    function doOnload() {
        doInitialize();
        doTerminate();
    }
    </script>
  </head>
  <body onload=doOnload()>
    Hello World, I am a SCO
  </body>
</html>
```

Content Organization

SCORM does not impose any restrictions on the file structure of your content. It only requires that certain non-content files exist in the package, including the `imsmanifest.xml` file and other schema related files (see Content Packages). The imsmanifest.xml file must exist in the top-level, or root directory, of the Package Interchange Format (PIF) file, which is a zip archive.

> **Best Practice**: It may be useful to organize the content into folders that are represented in the `resources` section of the manifest file. This will make it easier to repurpose and reorganize the content going forward.

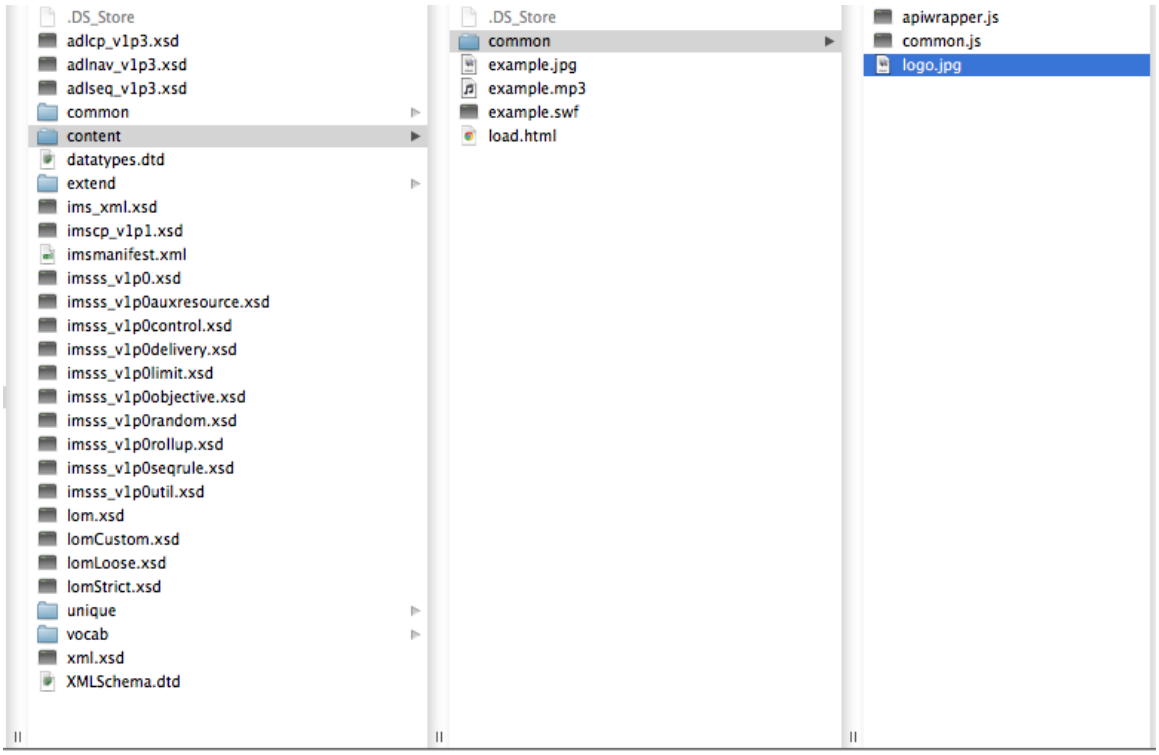
Even though SCORM lets you organize files however you wish, there are some suggestions that may help. The content of a SCORM 2004 content package is organized in related groups called resources. These resources are defined and referenced in the manifest file.

Here is the example we used in the Content Packages section:

```
<organizations>
    <organization>
         <title>Example Course</title>
         <item identifier="EXAMPLE-SCO" identifierref="SCO-RESOURCE">
              <title>Example SCO</title>
         </item>
    </organization>
</organizations>
<resources>
    <resource identifier="SCO-RESOURCE" adlcp:scormType="sco" type="webcontent"
              href="load.html" xml:base="content/">
       <file href="load.html"   />
       <file href="example.jpg" />
       <file href="example.swf" />
       <file href="example.mp3" />
        <dependency identifierref="LESSON_COMMON" />
    </resource>
    <resource identifier="LESSON-COMMON" adlcp:scormType="asset"
              type="webcontent" xml:base="content/">
        <file href="common/apiwrapper.js" />
       <file href="common/common.js" />
       <file href="common/logo.jpg" />
    </resource>
</resources>
```

In this example, we have one SCO and two Resources. A good plan would be to organize the content into folders, with each folder corresponding to a Resource.

Another tip is to put all the content you create into a separate folder, named *content* or something similar. So, in this example, we would have:



This structure makes it easy to keep everything organized and to be prepared for any repurposing or reuse that may be in your future plans.

Note: Many tools will handle all this organization for you. However, be aware that not everyone will use the same tools as you do, so do what you can to keep the file structure and organization neat and clean.

Best Practice: When possible, remove the redundancy of duplicated files in the content package. Use the dependency element (see Content Packages section and CAM 3.6.2) in the resource XML to encapsulate common resources and reuse within the content package.

LMS Management & Communication

4. Understanding the SCORM API

4.1 Introduction

The SCORM **Application Programming Interface (API)** is a standardized method for a sharable content object (SCO) to communicate with the learning management system (LMS) when a learner is interacting with a SCO. There is a specific set of information the SCO can set or retrieve. For example, it can retrieve information such as a student name, or set values such as a score.

To use the API, the content implements ECMAScript code, typically JavaScript, which makes API-specific calls to communicate with the LMS.

4.2 API Wrapper JavaScript file

To access the API in content, typically an API wrapper JavaScript file is included in the main HTML page of the SCO. This JavaScript file will find the LMS-provided API object and provide JavaScript functions to program the required functionality for your content. An API wrapper file is provided in the starter template and may be included in your project as a standard JavaScript include. The API wrapper code is also provided in the Appendix (see SCORM 2004 API Wrapper).

Note: The API wrapper files are typically used to make the life of the programmer a little easier. They are not required, and the programmer may directly communicate with the API. However, for the purposes of this document, we will assume the use of an API wrapper and reference functions found within it.

4.3 Initialization and Termination

To be a valid SCO, the content must do at least two things: Initialize and Terminate. The first API call that the content must make to the LMS is Initialize(). After all communication with the LMS is completed, the SCO must end the API session by calling Terminate(). Depending on the JavaScript library or API Wrapper you are using, the following calls might be made:

```
// called on page load
function onLoadPage()
{
    doInitialize();
}

// called on page unload
function onUnloadPage()
{
    doTerminate();
}
```

Note: If content does not need to communicate scoring or status information to the LMS, then Initialize() and Terminate() are the only required API calls for the SCO to be considered conformant. They may be called at any time after the content loads and before it closes.

5. CMI Data Model

This section explains storing and retrieving data about learner performance from and to the Learning Management System (LMS). Understanding the types of data that can be communicated via the SCORM data model enables you to discuss with your instructional system designer (ISD) what information you can retrieve from or store in the LMS.

In SCORM 2004, every LMS must implement certain functionality to ensure interoperability and achieve SCORM-conformance. One element of this functionality governs how data is retrieved and stored. The SCORM data model elements govern how data on learners' performance and interactions is retrieved and stored.

Note: Every SCO has a full set of data model elements, but it is not possible to access the data model elements of another SCO. For example, you cannot access the completion status of different SCOs in the course. There are ways to share certain information across SCOs: through the use of global objectives (see Section 11 Tracking across SCOs using Global Objectives) and a special data model element, named adl.data (see Section 5.3.1 Inter-SCO Data Storage). These elements allow the sharing of some status data and also a data bucket for sharing generic strings across SCOs.

A SCO must initiate all communication with the LMS. After the SCO has initiated communication with the SCORM API, requests to store or retrieve data from the LMS can be initiated by the SCO. The SCORM data model elements, described in detail in the SCORM RTE book (also see the section on the Run-Time Environment (RTE) Book), facilitate the collection of learner information as learners progress through a SCO. An LMS is required to support all of the data model elements, but you are not required to use any of them. As a programmer, you need to know what data can be communicated via the SCORM data model so you can assist your ISD in knowing what options are available.

5.1 When to Implement

The SCORM data model is used whenever you need to store or retrieve data related to the learner's session in the LMS. For example, you might want to retrieve the following information from the LMS:

- The learner's name for use inside the content (i.e., "Well done, Jane.")
- The last location in the content the learner viewed (i.e., "Do you want to start where you left off?") (see the Bookmarking Cookbook section)
- The learner's language, presentation, or other preferences

You may also want to store information in the LMS such as the learner's:

- Score
- Total time spent in a SCO
- Time spent in a single session of a SCO
- Completion status
- Responses to assessment items
- Interactions within a SCO
- Pass/fail status

Note: If your course design requires minimal tracking or learner interaction, no data model elements need to be stored. Again, it is important to work with the designer to understand what is required.

5.2 Examples

Table 5.1 provides a description and application of the most common SCORM data model elements, using the simple name and the *cmi* name. See CAM 4.1 or the section that describes Content Aggregation Model (CAM) Book in this document, for the complete description of the data model and list of elements with their allowed value formats.

Table 5.1 Common SCORM Data Model Elements

Data Model Element with *cmi* Name	Description	Application
Technical Data		
Entry *cmi.entry*	Indicates whether the learner has previously accessed the SCO so the run-time environment will know if data for the SCO exists or not. This value is initialized by the LMS and is read-only.	When learners enter a SCO for the first time, the element is set to *ab-initio*. If the learner is re-entering a suspended session, the element is set to *resume*.
Launch Data *cmi.launch_data*	Provides data specific to a SCO that the SCO can use for initialization. This value is initialized by the LMS using the data from the manifest file element `<adlcp:dataFromLMS>`.	Allows SCOs to be configured with data from the LMS at the time of launch. This data is defined in the manifest file element `dataFromLMS` (see CAM 3.4.1.14). For example, configuration data for scenarios can be passed via this element.
Location *cmi.location*	Represents a location in the SCO.	Used for book-marking the learner's position in a SCO in a given instance, allowing the learner to resume the SCO at the same point at which learning was suspended. This value is not interpreted by the LMS, but is made available to the programmer to implement features such as book-marking.

Data Model Element with *cmi* Name	Description	Application
Suspend Data *cmi.suspend_data*	Provides additional space to store and retrieve data between learner sessions.	If the learner starts the SCO, but does not complete it, the current state data (up to 64K characters) may be stored in this element. This value is not interpreted by the LMS, but is made available to the programmer to implement features such as book-marking.
Content Initialization		
Learner Name *cmi.learner_name*	Allows the SCO to present the name of the learner inside the content, in the form lastname, firstname.	Typically used to customize learning content, for example: "Welcome back Sgt Thomas." or "Nice work, Capt. Brown."
Score Reporting		
Completion Status *cmi.completion_status*	Indicates if the learner has completed the SCO.	The completion status [see Status and Scoring], determined by the ISD, can be based on a test score, navigation through content, completion activities, etc.
Interactions *cmi.interactions*	Describes a collection of learner responses, such as responses to questions or tasks for the purpose of measurement or assessment.	Frequently used in tests or quizzes to collect learner response information. [see Assessments, for more information on *cmi.interactions*.]
Objectives *cmi.objectives*	Specifies learning or performance objectives associated with a SCO. Usually mapped to Globals which may be shared across SCOs.	May be used to represent learning objective status and to impact sequencing decisions in the course.
Scaled Passing Score *cmi.scaled_passing_score*	Identifies the scaled passing score required to master the SCO. This field is set from the LMS using the value in `<adlcp:minNormalizedMeasure>`. This value is read-only.	Will be initialized to your minimum passing score and may be retrieved for reference.
Score *cmi.score.raw* *cmi.score.min* *cmi.score.max* *cmi.score.scaled*	Identifies the learner's score for the SCO. A SCO can only report one score. [see RTE 4.2.20]	This is typically the result of some interaction the learner has with the content where a numeric score is relevant. The score object is broken down into 4 sub-elements, with *scaled* being the most commonly used to represent a mastery percentage.
Success Status *cmi.success_status*	Indicates if the learner has mastered the SCO, as indicated by a *passed* or *failed* value.	The criteria, defined by the ISD, can be based on a percentage of interactions being passed or objectives being met, a score for a test or quiz, etc. See Status and Scoring for additional details on how this field is used.
Exit Data		
Exit *cmi.exit*	Indicates how the learner left the SCO. (see Exiting SCOs and Courses)	Can be used to impact sequencing decisions and determines if a SCO is suspended or exited normally.

Data Model Element with *cmi* Name	Description	Application
Session Time *cmi.session_time*	Identifies the amount of time the learner has spent in the current instance of the SCO.	The ISD defines the value and meaning of session time. The LMS uses this time to compute total time.
Total Time *cmi.total_time*	Stores the learner's cumulative time for all sessions of a specific SCO for a given learner attempt.	Stores the total time spent in every session of a given SCO, for a given learner.

5.3 How to Implement

The cmi data model is accessed through JavaScript calls in the content. In the API wrapper files we are using in this document (see Section 3.3.2 API Wrapper), there are two calls that are used when working with these elements: doSetValue and doGetValue. Both of these are defined in the APIWrapper.js file in the content package. A full set of API calls that are available can be found in RTE 3.1.

Values of the cmi data model are simple strings and numbers. Here are some examples in JavaScript.

```
// get the learner's name
var name = doGetValue("cmi.learner_name");

// set the score for the SCO
var score = ".85";
doSetValue("cmi.score.scaled", score);

// mark the SCO as passed
doSetValue("cmi.success_status", "passed");

// look up the bookmark of a SCO
var bookmark = doGetValue("cmi.location");

// store the current state data of the SCO to be used after resuming.
// 'save this data' refers to a string stored in the LMS that upon
// resumption of the course will be fetched and used to initialize the
// content
doSetValue("cmi.suspend_data", "save this data");
```

5.3.1 Inter-SCO Data Storage

Prior to SCORM 2004 4th Edition, SCOs had no visibility or access into information tracked by other SCOs or even different attempts on a given SCO. With 4th Edition, ADL has provided the *adl.data* data model element to allow for the sharing of sets of data across SCOs through a collection of data stores.

Data stores are associated with a SCO using the *<adlcp:data>* (see CAM 3.4.1.18 and RTE 4.3) extension element in the Manifest File. This element is the last element in the *<item>*

element and a SCO may be associated with many data stores. The following XML will share two data stores with a SCO.

```
<item identifier="SCO1" identifierref="RES1">
    <title>SCO with shared data</title>
    <adlcp:data>
        <adlcp:map targetID = "shared_data_1" />
        <adlcp:map targetID = "shared_data_2" />
    </adlcp:data>
</item>
```

From within the content, the *adl.data* is accessed similar to global objectives (see Section 11 Tracking across SCOs using Global Objectives). The data store is located by searching for it within an array of data store elements. In the Starter Template, a function called *findDataStore()* is provided. To access the data in the store, the following JavaScript is used:

```
var index = findDataStore("shared_data_1");
// grab the data
var sharedData = doGetValue("adl.data." + index  + ".store");
// store the data
doSetValue("adl.data." + index + ".store",
           "some data you would like to share");
```

The data stored in *adl.store* may be shared across content packages as well. An attribute *adlseq:sharedDataGlobalToSystem* in the *<organization>* element of the manifest controls if this data is accessible outside the scope of the content package. The default value is *true*, so be sure to set the value to false if you wish to restrict access.

```
<organization identifier="ORG-SAMPLE" adlseq:sharedDataGlobalToSystem="false">
```

6. Status and Scoring

6.1 Introduction

Each activity in SCORM 2004 has a status. As described in the section on global objectives (see Section 11 Tracking across SCOs using Global Objectives), both a SCO and an aggregation have a *primary objective*. This primary objective is an object holding status values related to the progress and success of the learner's interaction with the activity. Each SCO can set values in its own primary objective. The following information is stored in the primary objective:

- Success_status
- Completion_status
- Score (scaled, raw, min, max)
- Progress_measure

Note: Setting the score by itself does not have any immediate side effect in the course. It just sets the value, which is stored in the LMS. However, as noted in the next section, when used in combination with manifest file settings, the scaled score may impact success status.

Note that these are the same values defined in the CMI Data Model for statuses.

Note: The organization element in the manifest file is a special type of aggregation, sometimes called the "root" aggregation. Just like regular aggregations, the organization has a primary objective. This objective will ultimately contain the final status available to the LMS for the content package.

6.2 How to Implement

6.2.1 Numeric Scores

When you need to track a numeric score in a SCO, the score object of the primary objective is used. The score is calculated by the content. SCORM does not dictate how this score is calculated. That is left up to you as the developer, in coordination with the instructional designer. For example, to set the score to 85%, the following JavaScript code is used in the content:

```
doSetValue("cmi.score.scaled", ".85");
```

The element `cmi.score.scaled` must be a number between -1 and 1. It is typically the score of the content normalized to a percentage. The other elements of *cmi.score* are used to provide additional context only. These include *cmi.score.min*, *cmi.score.max*, *cmi.score.raw*. The min and max values may be used to define a range and the raw element should be a number within the range of min and max. See RTE 4.2.20 for examples.

6.2.2 Calculate the Success Status

A score in and of itself does not have any impact on the course. It should be combined with the Success Status and Sequencing. The Success Status represents if an activity is passed or failed. This can be set directly, using the data model API:

```
doSetValue("cmi.success_status", "passed");
```

Another method is to use some special XML in the manifest file to calculate whether the saved score represents a passed or failed attempt by the learner. This element is called *imsss:minNormalizedMeasure* and is detailed in CAM 5.1.7.1.1. When used in conjunction with the *satisfiedByMeasure* attribute in the primary objective, the pass/fail status of the activity can easily be controlled by the manifest. In the following example, any score of 60% or higher will result in a passing status.

Best Practice: Using the manifest to drive the success status of the activity is a really good method to use if you need more dynamic control over the passing threshold of a SCO. For example, a pre-assessment of a course may require 90% mastery, while the same content when used as a post-test may only require 80%. This XML method makes it easy to make alterations without the need to change content.

```
<imsss:primaryObjective objectiveID = "PRIMARYOBJ" satisfiedByMeasure = "true">
  <imsss:minNormalizedMeasure> 0.6 </imsss:minNormalizedMeasure>
</imsss:primaryObjective>
```

6.2.3 Completion and Progress

A SCO is either completed or not, depending on the progress of the learner. There are two data model elements (see CMI Data Model) available to the SCO to update progress.

cmi.progress_measure

This is used to indicate partial completion and also automatically update *cmi.completion_status*. Referencing the table in RTE 4.2.18, *cmi.progress_measure* has the following impact on *cmi.completion_status*:

cmi.progress_measure	cmi.completion_status
0	"not attempted"
1	"completed"
0 < value < 1	"incomplete" (typically, unless a *cmi.completion_threshold* is defined and the *cmi.progress_measure* >= *cmi.completion_threshold*)

cmi.completion_status

This may be set to "incomplete" or "completed." Default value is "not attempted." As the programmer, you are typically responsible for setting this value unless *cmi.progress_measure* is used.

Completion Threshold

It's also possible, though not as common, to define a completion threshold in the manifest file. In the SCORM books, Sequencing & Navigation 3.14 and CAM 3.4.1.15, ADL has provided a special element to control completion. This element has three attributes:

- **completedByMeasure** (optional, default value = false): Indicates whether the minProgressMeasure attribute's data value shall be used to determine completion. Setting this attribute to true will force the SCO to calculate the value of *cmi.completion_status* based on *cmi.progress_measure* and the *minProgressMeasure* attribute.

Note: In SCORM 2004 4th Edition, the syntax for Completion Threshold changed. In 3rd Edition, it was possible to set the threshold using the child value of the XML element: `<adlcp:completionThreshold>0.75</adlcp:completionThreshold>`. For 4th Edition, the attribute should be used as described in this document.

- **minProgressMeasure** (optional, default value = 1.0): The value used as a threshold to calculate completion status. Valid values range from 0.0000 to 1.0000. When defined, this value is compared to the value contained in *cmi.progress_measure*. If *cmi.progress_measure >= minProgressMeasure* (which is found in the read-only element *cmi.completion_threshold*), the SCO will be considered completed and *cmi.completion_status* will be updated accordingly.

- **progressWeight** (optional, default value = 1.0): Indicates weighting factor used during completion rollup of parent.

The following code is an example manifest entry for a SCO that is considered completed if the progress measure is 75% completed.

```
<item identifier="ITEM3" identifierref="RESOURCE3" isvisible="true">
    <title>Content 1</title>
    <adlcp:completionThreshold completedByMeasure = "true"
                               minProgressMeasure = "0.75" />
</item>
```

6.2.4 Reporting Scores for Multi-SCO Course

We've discussed how to set the score and completion for a SCO. However, most SCORM 2004 courses contain multiple SCOs. The course as a whole will need to ultimately report a status. This can be accomplished by using Rollups and/or Globals to calculate the scores of aggregations and propagate up the activity tree to the root aggregation.

Sequencing & Navigation

7. Control Modes

7.1 Introduction

In SCORM 1.2, the learner could choose any SCO at any time by clicking on a desired entry in the LMS-provided table of contents. In SCORM 2004, Sequencing gives you, the programmer, the option to control the order in which the SCOs in a given Aggregation is presented. If you do not need to implement sequencing, the default settings will allow learners to choose any SCO at any time.

However, if you need to control the order in which your learners experience the SCOs within a given aggregation, SCORM Sequencing provides several options called Control Modes that you set to *true* or *false*. Table 7.1 describes the most common control modes.

Table 7.1 Common Control Mode Descriptions

Control Mode	Default Value	Description	SCORM Book
Choice	true	Allows learners to select the order in which they view the content.	SN 3.2.1
Flow	false	Requires learners to view the content in an order defined by the instructional designer. A combination of Navigation requests and sequencing initiates the delivery.	SN 3.2.3
Choice Exit	true	Controls if learner may select an activity outside the active aggregation via choice. Typically, all other portions of the activity tree are hidden and the active aggregation appears as the top-level in the Table of Contents.	SN 3.2.2

Details and information on additional modes can be obtained in SN section 3.2. We will discuss the most commonly used modes in this guide.

7.2 When to Implement

Every course uses Control Modes. Even if you do not explicitly add the XML in the Manifest File to define the control modes of an aggregation, a control mode exists. The default control modes are displayed in Table 7.1 above.

7.3 Example

In Figure 7.1 we have a simple course structure. From the Root Aggregation, we have a series of SCOs (indicated in gold) related to changing a flat tire in a vehicle. All the SCOs exist at the

same level as children of the root aggregation. Depending on the design SCOs may be presented in a linear order or the instructional designer (ISD) may choose to allow the learners to pick and choose the order these lessons are presented.

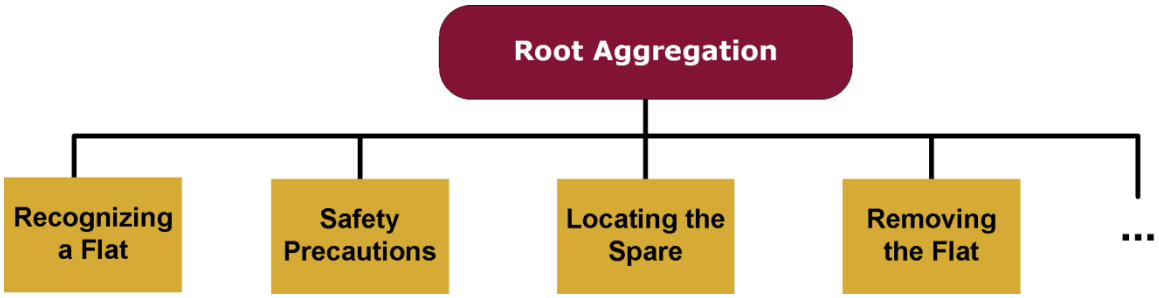


Figure 7.1 Basic Sequencing Structure (SCOS indicated by gold boxes)

7.4 How to Implement

Control modes are implemented in the manifest file by editing the *controlMode* element, which is the first entry in the sequencing XML of an aggregation. See CAM 5.1.2 for details on the *controlMode* element.

For example, to allow the learner to experience the SCOs in any order he/she wants, the control mode of the Root Aggregation in Figure 7.1 might look like this:

```
<imsss:controlMode flow="false" choice="true"/>
```

However, the ISD may feel it's important that the learner experience the SCOs in the order they are listed above. To accomplish this, the following control would be used:

```
<imsss:controlMode flow="true" choice="false"/>
```

As mentioned, control modes are defined at the aggregation levels in the course structure (also called the activity tree) and affect only the immediate children of that aggregation. In SCORM, a SCO is always a child and will never be a parent with a SCO beneath it. Aggregations, however, can be both parents and children. Remember that aggregations are simply collections of SCOs and other aggregations. An easy way to remember how modes apply in sequencing is that all of the children will follow the control mode defined in the parent; no child is special. For example, if an aggregation defines control mode *choice* as "true", then all the child SCOs or child aggregations

Best Practice: It is important to work closely with the instructional designer when selecting control modes and deciding how to implement the sequencing of a course. These mode selections should be driven by the ISD's design. As a programmer, become familiar with their meanings and impact on the content so you can best realize the desired output and give advice on possibilities and limitations.

will be available for selection in the table of contents.

Best Practice: Though it's possible to set both flow and choice to true, be careful as this can create problems. These two modes are usually in conflict with each other. Choice is learner-driven, while Flow is design driven. Enabling Choice in an aggregation will allow the learner to bypass some important design features the ISD may have prescribed.

There is no inheritance of control modes, so the modes set at the parent level apply only to that parent's immediate children (and not even to itself). A child that is an aggregation will have its own defined control modes that its children will follow.

For example, Figure 7.2 depicts a series of SCOs under a root aggregation. Each of the SCOs in this root aggregation will follow the set of rules defined for the root aggregation. If you wanted to allow learners to choose *Recognizing a Flat* or *Safety Precautions* before going on to the other SCOs, you would have to create a new parent for them. Figure 7.2 depicts the same content with a new parent aggregation called *Safety* that includes the *Recognizing a Flat* and *Safety Precautions* SCOs as children. Rules can now be assigned to the Root Aggregation that will apply only to the Safety Aggregation and the *Locating the Spare*, *Removing the Flat* and subsequent SCOs. A unique set of rules can now be added to the *Safety* aggregation.

Best Practice: Any time you need to define a special mode for a SCO or aggregation, you need to create a new parent for it.

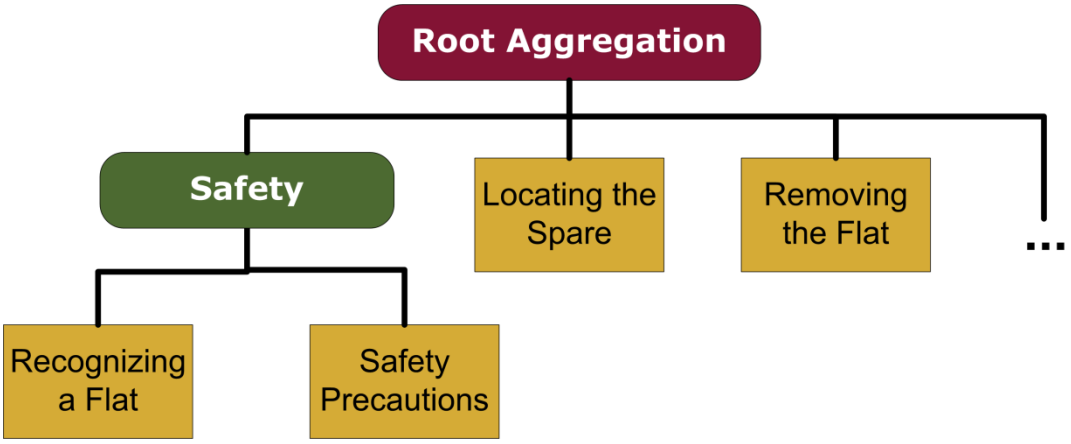


Figure 7.2 Basic Sequencing Structure with an additional Aggregation

For Figure 7.2, you might write the following rules for control mode:

- For the Root Aggregation, learners must view all of the items in order. They can go back at any time.
  - `<imsss:controlMode flow="true" choice="false"/>`

- For the Safety Aggregation, allow learners to choose *Safety Precautions*, *Recognizing a Flat,* or both.
    - `<imsss:controlMode flow="false" choice="true"/>`

Note: Sometimes, the ISD will dictate a more dynamic control mode than SCORM allows. For example, the design might dictate that the learner experience lessons in a certain order before a quiz. However, once taken, the learner can review the material in any order before moving on. This is not immediately accomplished in SCORM 2004 using control modes as mode values are static and can't be changed throughout the course. There are ways to accomplish designs like this. See cookbook section on The Menu SCO for an example.

Best Practice: Control Mode Choice Exit is not as common as flow and choice. However, there is one very important use of Choice Exit that needs to be noted. In the table of contents, the top-level item (the root organization) is rendered in the table of contents as a clickable link to comply with a component of the UI conformance requirements of SCORM. This is problematic as the learner may click the top link anytime during the session. The result is that the activity tree is started over from the beginning and the current session will probably end up in an undefined state. To overcome this, choiceExit should be set to false in the course's organization's control mode element.

Note: This method is not currently interoperable across LMSs due to a gray area in the conformance criteria of SCORM 2004 4th Edition. To do this interoperably, a hidden aggregation must be added as a child of the root organization element. Setting isvisible="false" in this new aggregation's item element and adding an attribute of choiceExit="false" to the control mode element will hide the clickable link related to the organization element from the learner, yet still present the entire organization's activities to the learner in the Table of Contents. Your real content will be a child to this new aggregation. This method should work in all LMSs. Test on your LMS to see how it functions.

7.5 Related Information

To read more on control modes and related topics, see the sections on Control Modes in the SN 3.2 and CAM 5.1.2 books and also Constrain Choice Considerations in SN 3.3 and CAM 5.1.10.

8. Navigation

8.1 Introduction

Navigation is the process in which content (see the Sequencing section) is initiated. A navigation request, as detailed in section 4.4.3 of the SN book, is the process of initiating events, which results in the identification of learning activities (SCOs, Organizations or Clusters) for delivery. Both learner and system may initiate these events.

8.2 Examples

Some conceptual examples of these requests are:

- Continue to the next activity
- Suspend this entire session
- Exit (finish) this course
- Jump to the post test

8.3 When to Implement

As the programmer, it's very important to understand when navigation requests occur. The timing of navigation events must adhere to the design the ISD provides. For every SCO (see Sharable Content Object section), you must understand and control when navigation requests are allowed to take place.

The main set of actions available through navigation requests are:

- **previous** - request the previous activity
- **continue** - request the next activity
- **exitAll** - exit/finalize the attempt on the course
- **suspendAll** - suspend and close the current session
- **choice** - target a specific activity to launch. Allowed based on control mode (see Control Modes section) "choice" setting.
- **jump** - target a specific activity to launch. Always allowed.

Less commonly used actions are:

- **exit** - terminate the current activity normally
- **abandon** - terminate abnormally. Activity may not be resumed.
- **abandonAll** - terminate attempts on all activities. May not be resumed.

8.4 How to Implement

There are four ways to initiate navigation requests.

8.4.1 LMS Navigation Elements

The Learning Management System (LMS) will provide some navigation elements in its own user interface (UI). These include *previous* and *continue* (usually shown as previous/next arrows) and some form of *exit*, *exitAll*, *abandon*, *abandonAll*, *suspendAll*. You should become familiar with the target LMS and understand the requests associated with each UI element. The LMS UI can be customized to display only the elements desired for a given SCO. This customization is done through the use of the *<adlnav:presentation>* elements in the Manifest File, where specific navigation controls may be hidden. This *adlnav:presentation* element is placed after the *<sequencing>* element of a SCO.

In the example below, only the *suspendAll* navigation element will be available in the LMS provided navigation UI.

```
<item identifier="SCO-1" identifierref="RES-SCO_1" isvisible="true">
<title>SCO 1</title>
<adlnav:presentation>
  <adlnav:navigationInterface>
    <adlnav:hideLMSUI>continue</adlnav:hideLMSUI>
    <adlnav:hideLMSUI>previous</adlnav:hideLMSUI>
    <adlnav:hideLMSUI>abandon</adlnav:hideLMSUI>
    <adlnav:hideLMSUI>exit</adlnav:hideLMSUI>
    <adlnav:hideLMSUI>abandonAll</adlnav:hideLMSUI>
    <adlnav:hideLMSUI>exitAll</adlnav:hideLMSUI>
  </adlnav:navigationInterface>
</adlnav:presentation>
</item>
```

Best Practice: It is suggested to only allow a *suspendAll* navigation device from the LMS. This allows the learner to explicitly pause a course (to take a break) and resume later. On occasion, *previous* and *continue* may be appropriate. However, in many cases, it may be preferred to embed *previous* and *next* navigation into the content itself. This allows for a more consistent interface for the learner. See the section 8.4.3 Navigating from within Content for details on how to navigate from content. Also see the Cookbook section on The Menu SCO for additional options on navigating within the course.

8.4.2 Table of Contents

The LMS is required to display a table of contents that represents the activity tree of the Content Packages in this document. When the learner selects an activity via the table of contents, a *choice* navigation request is initiated and the selected activity is launched if available.

8.4.3 Navigating from within Content

Navigation requests may be initiated from within the content itself. This is done through a special data model element, `adl.nav.request`. Programming calls are made in JavaScript to initiate these requests. The syntax of the request is as follows:

```
doSetValue("adl.nav.request", requestToken); // navigation request set
doTerminate(); // navigation request processed after Terminate
```

The tokens available for use in SetValue are the same actions listed above in Section 8.3. The tokens of *choice* and *jump* have special syntax to designate the targeted activity.

```
doSetValue("adl.nav.request", "{target=<ACTIVITY_ID>}choice");
doSetValue("adl.nav.request", "{target=<ACTIVITY_ID>}jump");
```

ACTIVITY_ID is the *identifier* attribute found in the manifest file for the *<item>* element associated with the targeted activity.

Note: *jump* is a new request in 4th Edition. It was introduced to allow content to have more navigation control. A choice request is only allowed if the parent cluster of a SCO has choice enabled in its control mode (see Section 7. Control Modes). To enable content to target an activity for launch, regardless of control mode, the jump request was introduced. Other than this, they exhibit identical behaviors.

Best Practice: The most common use of adl.nav.request is to initiate a *continue* request. This is a very clean and interoperable way to initiate navigation from within the content of the SCO. It does not impact reuse and does not violate any best practice of keeping the SCO as a standalone entity. It simply means "This activity is done, move the learner to the next available activity." If there are no more activities to present to the learner, the course is exited and the equivalent of an *exitAll* navigation request is sent.

The following code should be placed within the SCO at a section that is executed when the learner is finished with a given attempt on the SCO.

```
doSetValue("adl.nav.request", "continue");
doTerminate();
```

8.4.4 Post-condition Rule Actions

Actions in sequencing rules (see Sequencing & Navigation section in this document) will have a similar effect on the content as initiating a navigation request. These requests may be initiated through the use of post-condition rules. These include *continue*, *previous*, and *exitAll*.

To issue a continue sequencing request if a SCO is satisfied, the following post-condition rule may be implemented:

```
<imsss:sequencingRules>
  <imsss:postConditionRule>
    <imsss:ruleConditions conditionCombination="all">
      <imsss:ruleCondition condition="satisfied" />
    </imsss:ruleConditions>
    <imsss:ruleAction action="continue" />
  </imsss:postConditionRule>
</imsss:sequencingRules>
```

9. Sequencing

9.1 Introduction

Sequencing is the process in which content objects are selected by the LMS for delivery to the learner. Sequencing is typically initiated by a navigation request, as described in section 4.4.3 of the SN book (also see Navigation section in this document). During the sequencing process, rules are evaluated and an activity (SCO or aggregation) is identified for delivery. Sequencing is the most complex part of SCORM. In this guide, we will break down the most commonly used pieces of sequencing and give you the information needed to be successful.

Under the blanket of sequencing, there is a lot of functionality. Some of this functionality is complex enough to warrant its own section in this document (Tracking across SCOs using Global Objectives, Control Modes, and Rollups), and we will address them separately. .

In this section, we will cover Sequencing as it relates to moving from one activity to another and also address some miscellaneous sequencing items (Limit Conditions, Randomization, and Delivery Controls). For a full list of sequencing components, see SN 3.1 and CAM 5.1.1.

9.2 Examples

Some conceptual examples of sequencing are:

- Move from one SCO to the next
- Retry a cluster if failed
- Exit a cluster in the middle
- Skip an activity that has already been attempted

9.3 When to Implement

If you do not need to control the order in which activities are presented, the default Control Modes in SCORM 2004 will act very similarly to SCORM 1.2. That is, the SCOs will be available for selection by the learner in any order they wish. If you need to control the order in which activities are presented to the learner, then sequencing must be implemented. Work closely with the designer to understand how a learner would flow through the course in all scenarios. To sequence in SCORM, the Control Mode *flow* should be set to "true" and typically Control Mode *choice* should be set to "false."

9.4 How to Implement

In sequencing, you basically need to understand how to use three types of condition rules provided by SCORM: pre-conditions, post-conditions, and exit-conditions. These rules, in combination with navigation requests (see the Navigation section in this document) are all that is needed to implement the majority of sequencing. Sequencing rules are defined in detail in the SN book (see SN 3.4).

All sequencing rules have the same syntax. In the sequencing element of an activity, found in the manifest file, there is a *sequencingRules* element, which may contain any number of pre, post, and exit condition rules. Here is an example of the syntax:

```
<imsss:sequencingRules>

  <imsss:preConditionRule>
    <imsss:ruleConditions conditionCombination="all|any">
      <imsss:ruleCondition condition="someCondition" />
      <imsss:ruleCondition condition="someOtherCondition" />
    </imsss:ruleConditions>
    <imsss:ruleAction action=
                    "skip|disabled|hiddenFromChoice|stopForwardTraversal" />
  </imsss:preConditionRule>

  <imsss:postConditionRule>
    <imsss:ruleConditions conditionCombination="all|any">
      <imsss:ruleCondition condition="someCondition" />
    </imsss:ruleConditions>
    <imsss:ruleAction action=
                    "exitParent|exitAll|retry|retryAll|continue|previous" />
  </imsss:postConditionRule>

  <imsss:exitConditionRule>
    <imsss:ruleConditions conditionCombination="all|any">
      <imsss:ruleCondition condition="someCondition" />
    </imsss:ruleConditions>
    <imsss:ruleAction action="exit" />
  </imsss:exitConditionRule>

</imsss:sequencingRules>
```

Let's break it down into the components of a sequencing rule.

First, rule conditions are either combined using AND or OR logic. This is done using the *conditionCombination* attribute in the *imsss:ruleConditions* element. The values of "all" and "any" correspond to AND and OR.

Conditions are listed as children of the *imsss:ruleConditions* element, using the *imsss:ruleCondition* elements. There are three important attributes used in this element:

- condition - the condition being tested
- operator - may have a value of "not" to add logical NOT to condition

- referencedObjective - if comparing the condition to the value in a local objective (see Tracking across SCOs using Global Objectives), the identifier of the local objective is used here.
- measureThreshold - When using *objectiveMeasureGreaterThan* or *ObjectiveMeasureLessThan*, this attribute holds the comparison value.

Best Practice: It's important to understand how to implement a logical NOT in sequencing conditions. In SCORM, the condition of "not satisfied" means "failed." It does not mean "a value other than passed," which may be counter-intuitive compared to other languages. For example, say you want to skip an activity if the learner has failed an optional pre-assessment. It may seem like this code should work, but beware! It will not.

```
<imsss:preConditionRule>
    <imsss:ruleConditions conditionCombination="any">
      <imsss:ruleCondition operator="not"
                           condition="satisfied"
                           referencedObjective="obj-pre" />
    </imsss:ruleConditions>
    <imsss:ruleAction action="skip" />
  </imsss:preConditionRule>
```

This example only checks if the pre-assessment was failed. If the optional pre-assessment was skipped, the referenced objective [see Tracking across SCOs using Global Objectives on how to use them] "obj-pre" will have a value of "unknown." Therefore, you need to add a second condition:

```
<imsss:preConditionRule>
    <imsss:ruleConditions conditionCombination="any">
      <imsss:ruleCondition operator="not"
                           condition="objectiveStatusKnown"
                           referencedObjective="obj-pre" />
      <imsss:ruleCondition operator="not"
                           condition="satisfied"
                           referencedObjective="obj-pre" />
    </imsss:ruleConditions>
    <imsss:ruleAction action="skip " />
  </imsss:preConditionRule>
```

Figure 3.4a from the SN book, shown below, explains how these values fit together:

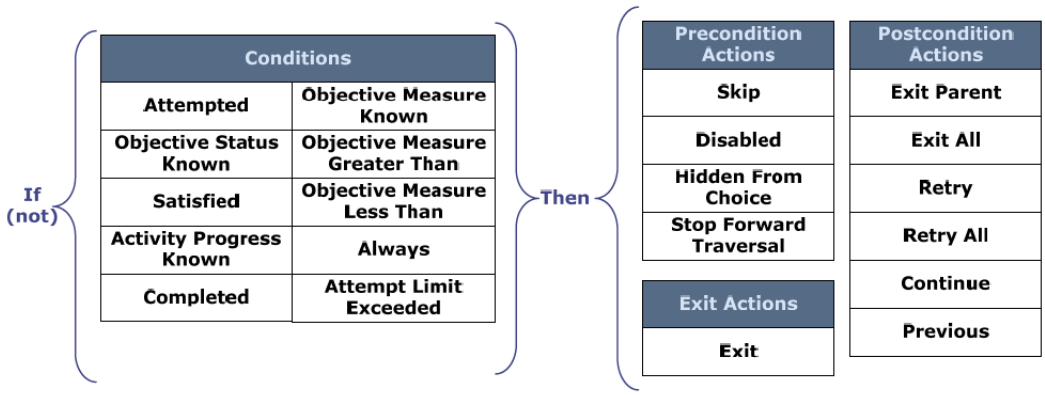


Figure 3.4a: Sequencing Rule Conditions and Actions

The conditions are documented well in Table 3.4.2a of the SN book. Here is a simplified table explaining the conditions:

Condition	Description
always	Always True
satisfied	True if activity or referenced objective is passed
completed	True if activity or referenced objective is completed
attempted	True if activity has been attempted
objectiveStatusKnown	True if the activity or referenced objective has a satisfied status is not unknown.
objectiveMeasureKnown	True if the activity or referenced objective has a normalized measure (score.scaled) is not unknown
objectiveMeasureGreaterThan	True if the activity or referenced objective has a normalized measure greater than the measureThreshold
objectiveMeasureLessThan	True if the activity or referenced objective has a normalized measure less than the measureThreshold
activityProgressKnown	True if the activity or referenced objective is in progress
attemptLimitExceeded	True if the number of attempts on the activity is greater than or equal to any defined attempt limit on the activity

Note: You can program multiple sequencing rules for an activity. They will be evaluated in top-down order.

9.5 Pre-Condition Rules

The main actions taken via a pre-condition rule are to keep the learner from having access to a given activity. The three most commonly used actions are:

- **skip** - skip over this activity and select the next available

- **disabled** - disallows an activity for delivery of any kind. Typically seen as grayed out in Table of Contents. (see Prerequisites Cookbook section)
- **hiddenFromChoice** - disallows activity as target of choice request. Will be grayed out or completely hidden in table of contents.

For example, to skip an activity if it's already been attempted, the following rule should be used:

```
<imsss:preConditionRule>
   <imsss:ruleConditions conditionCombination="any">
     <imsss:ruleCondition condition="satisfied" />
   </imsss:ruleConditions>
   <imsss:ruleAction action="skip" />
 </imsss:preConditionRule>
```

Note: Pre-Condition rules are continuously evaluated. This is in contrast to Post and Exit-Condition rules which are evaluated only after an activity Terminates. The reason behind this is that the execution of some of the actions such as *disabled* and *hiddenFromChoice* cannot be tied to a specific point in time.

9.6 Post-Condition Rules

Post-Condition rules are executed when an activity terminates. They are executed each time a SCO terminates. The following are the typical actions that can be taken:

- **exitParent** - Exit the current aggregation and execute post-condition rules of the parent
- **exitAll** - Terminate this attempt on the course
- **retry** - Retry the current activity. Note: All prior attempt data for this activity will be erased and a new attempt generated.
- **retryAll** - Retry the entire activity tree
- **continue** - Sequence to the next available activity in the tree
- **previous** - Sequence to the prior activity as available

Note: Post-Condition rules on an aggregation are not automatically evaluated. They are evaluated if a child activity executes an *exitParent* action in its own post-condition rule or if the aggregation's own Exit Condition rule executes an *exit* action.

9.7 Additional Sequencing Elements

9.7.1 Limit Condition

Sometimes you may wish to limit the number of attempts a learner may have on an activity. Using limit conditions may help you achieve this design. The following XML element may be inserted immediately after any sequencing rules to limit the activity to one attempt:

```
<imsss:limitConditions attemptLimit="1"/>
```

Best Practice: An activity may not be delivered more than its defined attempt limit. Sequencing does not provide an alternate activity or action if the attempt limit threshold is met. Typically the LMS will only show a message saying that the activity was not available for delivery. It's up to you as the programmer to use sequencing rules, specifically with condition *attemptLimitExceeded*, as defined above, to send the learner to an appropriate alternative activity.

9.7.2 Randomization Controls

In some cases, you may wish to randomize the order in which content is presented to the learner. For example, you may have two versions of an assessment and you want the learner to only be presented with one of them. This can be accomplished through the use of randomization controls (see SN 3.12). Randomization XML is placed before Delivery Controls on an aggregation. It does not make sense in the context of a SCO. The most common example is to reorder all the children prior to delivery:

```
<imsss:randomizationControls randomizationTiming="onEachNewAttempt"
                             reorderChildren="true"/>
```

Best Practice: If you want to only deliver one of the activities in an aggregation when using randomization controls, you will need to use post-condition rules to exit the aggregation after the learner takes the randomized activity presented to them. This will prevent the remaining sibling activities from being delivered. The following XML could be placed in the sequencing XML of each child in the aggregation.

```
<imsss:postConditionRule>
    <imsss:ruleConditions conditionCombination="any">
      <imsss:ruleCondition condition="always" />
    </imsss:ruleConditions>
    <imsss:ruleAction action="exitParent" />
  </imsss:postConditionRule>
```

9.7.3 Delivery Controls

There are three attributes that can be set in Delivery Controls.

- **tracked** (SN 3.13.1) - Whether or not the LMS manages tracking status information. Default = true.
- **completionSetByContent** – (SN 3.13.2) - If true, the content is required to set completion status (CMI Data Model). If false, the activity is marked as completed automatically on termination. Default = false.
- **objectiveSetByContent** – (SN 3.13.3) - If true, the content is required to set satisfied status (CMI Data Model). If false, the activity is marked as passed automatically on termination. Default = false.

Note: The attributes *completionSetByContent* and *objectiveSetByContent* allow non-communicative content (PDFs, Images, PPTs, etc.) to be easily used in SCORM without the need for programming additional JavaScript in the HTML. Also note that even if these attributes have their default values of false, that any statuses set by the content will always be honored.

9.7.4 Sequencing Collections

The XML for sequencing can become quite verbose, especially if sequencing designs are repeated throughout the course. To remove duplication, sequencing collections may be used. This is described more fully in the Sequencing Collections in the Cookbook section.

10. Tracking across SCOs using Global Objectives

10.1 Sequencing Objectives

Some terms (e.g., objective, primary objective) used to signify a specific function of instruction could have different meanings in SCORM related to sequencing your content. You should keep in mind the definitions of these words within the context of SCORM sequencing.

In sequencing, the variables that can store information about one SCO in the LMS that can be retrieved for later use are called "objectives," (SN 3.10). These are not to be confused with *learning objectives*, which in traditional instructional design, are used to measure the attainment of knowledge, skill, or ability in accordance with a predefined behavior, a prescribed condition, or an achievement standard. When discussing your sequencing behaviors with an ISD, make sure you are both referring to objectives in the same way to avoid confusion. As a programmer, you should consider these sequencing objectives as "variables" in which some information may be stored and shared with other activities.

Each SCO can set or read multiple objectives, and a single objective can be set or read by multiple SCOs. Objectives contain the following information. Note that these are the same values defined in the CMI Data Model for statuses.

- success_status
- completion_status
- score (scaled, raw, min, max)
- progress_measure

10.2 Examples

Sequencing objectives may be used to track information at a level more granular than the SCO itself. An objective may be used to:

- Track the status of parts of Assessments within a SCO for the purpose of remediation
- Share the score of one SCO with another SCO

10.3 When to Implement

Objectives should be implemented any time you need to share tracking information from one activity with another activity or if you need to persist the status of an activity across multiple attempts.

10.4 How to Implement

To implement objectives, you will be using a combination of programming inside the SCO (using JavaScript) and also at the manifest level (using XML). Before looking at code, we need to take a step back and understand how objectives are viewed from within each context.

As mentioned, an activity may contain multiple objectives. But there is one special objective called the *primary objective*. This refers to the objective containing the activity's own status values. The remaining objectives are sometimes referred to as secondary objectives, though that is not an official name.

10.5 Local vs. Shared Global Objectives

There are two types of objectives: *local* and *shared global*. They are typically used in conjunction with each other. See SN 3.10.1 for details. Local objectives are typically defined at the activity level through definitions in the manifest file (see examples below). Objectives can be stored and retrieved by JavaScript in the SCO and accessed by sequencing rules on the LMS (see the Sequencing section in this document). Local objectives are typically mapped to a shared global objective through the use of the *imsss:MapInfo* element (see Defining Objectives in the Manifest). Shared global objectives exist in the namespace inside the content package, and may be shared with other activities by mapping to local variables in other activities. Also, remember that each SCO and aggregation has a special local objective, the *primary objective*, which contains the core status of that activity (see section 6 Status and Scoring. The primary objective can also be mapped to a shared global.

Best Practice: As discussed in the content packaging section of this guide, shared global objectives may be scoped to the namespace of the entire LMS. This is through the use of the Objective Global to System attribute in the Organization [see Best Practice in Content Package Organizations]. Be very careful when using the default value of this attribute (True) as the global namespace may become cluttered.

10.6 Defining Objectives in the Manifest

Primary and secondary objectives are defined in the *imsss:objectives* element as a child of the *imsss:sequencing* element.

```
<imsss:sequencing>
   <!-- other sequencing rules go here -->
<imsss:objectives>
```

```
        <imsss:primaryObjective objectiveID="obj-primary" satisfiedByMeasure="false">
          <imsss:mapInfo targetObjectiveID="obj-global-1" />
        </imsss:primaryObjective>

        <imsss:objective objectiveID="obj-local-1 " satisfiedByMeasure="false">
          <imsss:mapInfo targetObjectiveID="obj-global-1" />
        </imsss:objective>

      </imsss:objectives>
      . . .
      </imsss:sequencing>
```

In this example, we have defined a primary objective and mapped it to a shared global named *obj-global-1*. We have also defined another local objective, *obj-local-1,* and mapped it to the shared global objective *obj-global-1*.

Note: Even though we give the primary objective an ID, this identifier is really never used in practice. Only the identifiers of the secondary objectives are important.

Best Practice: There is no real restriction on the naming of the objective identifiers. However, as a best practice, choose a naming convention that makes sense for your organization. It is a good idea to make the global identifiers something that will be unique universally. This can be done with a globally unique identifier (GUID) or using any local conventions. Also, since objectives can represent learning objectives and variables, many have opted to use prefixes like "obj-" and "var-" when naming objectives.

10.7 Understanding Mappings

When a local objective is mapped to a shared global objective, permissions must be defined for reading from and writing to the global objective. The *imsss:mapInfo* element lets the programmer control access to the Success Status and Normalized Measure (score) of an objective through the use of four attributes, each having a value of true or false:

- readSatisfiedStatus (default value = true)
- writeSatisfiedStatus (default value = false)
- readNormalizedMeasure (default value = true) f
- writeNormalizedMeasure (default value = false)

10.8 SCORM 2004 4th Edition Extended Global Objective Information

Up until SCORM 2004 4th Edition, global objectives only held values for Success Status and Score. 4th Edition has extended this to cover all the elements of the *cmi.objectives* data model (see CMI Data Model). These additional elements include:

- Completion Status
- Raw Score
- Min Score
- Max Score
- Progress Measure

However, since these elements were not part of the original IMS Sequencing specification for objectives, ADL had to add an extension to sequencing. A new element, *adlseq:objectives* was added to allow this additional information to be mapped to global objectives. The *adlseq:objectives* element is placed immediately after the *imsss:objectives* element. Using our example above, the following code allows for the Completion Status of the SCO's primary objective to be written to shared global *obj-global-abc* and the Progress Measure of local objective *obj-local-xyz* to be written to global *obj-global-xyz*.

```
<imsss:objectives>
  <imsss:primaryObjective objectiveID="obj-primary" satisfiedByMeasure="false">
    <imsss:mapInfo targetObjectiveID="obj-global-abc"
                   writeSatisfiedStatus="true" />
  </imsss:primaryObjective>
  <imsss:objective objectiveID="obj-local-xyz " satisfiedByMeasure="false">
    <imsss:mapInfo targetObjectiveID="obj-global-xyz"
                   writeSatisfiedStatus="true" />
  </imsss:objective>
</imsss:objectives>
<adlseq:objectives>
  < adlseq:objective objectiveID="obj-primary">
    < adlseq:mapInfo targetObjectiveID="obj-global-abc"
                     writeCompletionStatus="true" />
  </ adlseq:objective>
  < adlseq:objective objectiveID="obj-local-xyz">
    < adlseq:mapInfo targetObjectiveID="obj-global-xyz"
                     writeProgressMeasure="true" />
  </ adlseq:objective>
</ adlseq:objectives>
```

Note: The last SCO to write a completion status to a global objective is the value that finally gets stored there.

10.9 Accessing Objectives in the Content

Local objectives are typically accessed in the SCO using JavaScript. The primary objective is a special objective and contains the core statuses of the activity. To access these, you will use the related CMI Data Model elements (see the CMI Data Model section in this document).

```
// read the success status of the primary
var success = doGetValue("cmi.success_status");

// write the progress measure of the primary to 50% completion
doSetValue("cmi.progress_measure", ".50");
```

For objectives other than the primary, the *cmi.objectives* data model element is used. The content must know the *objectiveID* of the local objective. It does not need to know the global's ID as it always accesses it via the local objective to which it is mapped.

To access a local objective, you must search for it in the array of objectives. Using the APIWrapper from the Starter Template, you use the *findObjective* JavaScript function.

```
var index=findObjective("obj-local-xyz");
```

Now that you have the index, the information may be accessed in *cmi.objectives*.

Note: The index must be searched for as the order in which they are found in the objectives array is not guaranteed to follow the order defined in the manifest.

```
// set the success_status
doSetValue("cmi.objectives." + index + ".success_status", "passed");

// read the completion_status
var status = doGetValue("cmi.objectives." + index + ".success_status");
```

11. Rollups

11.1 Introduction

Activities in SCORM are organized in a hierarchical tree structure, called the Activity Tree. There are an infinite number of structures and designs that are possible in SCORM 2004, but at the end of the day, there needs to be a status reported for the root of this tree (i.e., the organization, described elsewhere (see Content Packages). The mechanism for calculating and bubbling up statuses through the activity tree is called Rollups.

Rollup rules (see CAM 5.1.6 and SN 3.7) are used to report the status of children to their parents. Each aggregation conceptually asks its children what their status is. The aggregation can then determine its status and report its status up the tree until the root aggregation knows the status of each of its children. Like standard sequencing rules, rollup rules follow an if/then pattern using conditions defined from the limited vocabulary shown in SN Figure 3.7a, reproduced below. Rollup rules apply to a defined subset of the children.

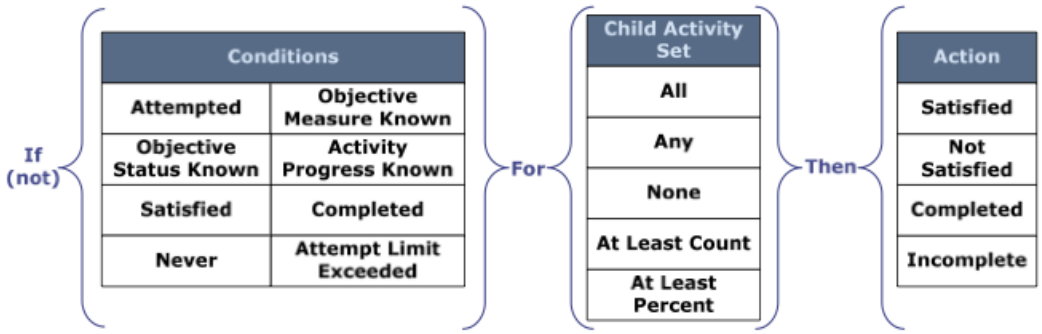


Figure 3.7a: Rollup Rule Child Activity Set, Conditions and Actions

11.2 Examples

Some conceptual examples of rollups are:

- Satisfy (Pass) the aggregation if all the children are satisfied
- Complete the aggregation if 75% of the children are completed
- Fail an aggregation if any of the children are failed (Not Satisfied)

11.3 When to Implement

As the programmer, you need to define the Rollup Rules to meet the design requirements provided by the ISD that are not covered by defaults. It will be up to you to understand the impacts and possibilities of Rollups and discuss options with the designer.

Rollups always exist whether explicitly defined or not. If no rules are defined, the following default rules will be applied in order.

1. Satisfied Status:
   - If all children have a known status (passed or failed) and any failed, then not satisfied
   - Otherwise, If all satisfied, then satisfied

2. Completion Status:
   - If all children have a known completion status (completed or incomplete) and any incomplete, then incomplete
   - Otherwise, if all completed, then completed

3. For numeric scores, the default is to calculate the weighted average of all the scores of the children.

11.4 How to Implement

With Rollups, you need to consider the two main statuses of an activity: Completion and Satisfied Statuses. For each aggregation, ask the following four questions:

1. What condition(s) would make this aggregation satisfied?
2. What condition(s) would make this aggregation not satisfied (failed)?
3. What condition(s) would make this aggregation completed?
4. What condition(s) would make this aggregation incomplete?

Once these four questions are answered, Rollup Rules may be written to satisfy them all. Let's look at a few examples using the ones mentioned above:

1. Satisfy the aggregation if all the children are satisfied

```
<imsss:rollupRule childActivitySet="all">
    <imsss:rollupConditions conditionCombination="any">
      <imsss:rollupCondition condition="satisfied"/>
    </imsss:rollupConditions>
    <imsss:rollupAction action="satisfied"/>
</imsss:rollupRule>
```

2. Complete the aggregation if 75% of the children are completed

```
<imsss:rollupRule childActivitySet="atLeastPercent" minimumPercent="0.75">
    <imsss:rollupConditions conditionCombination="any">
      <imsss:rollupCondition condition="completed"/>
    </imsss:rollupConditions>
    <imsss:rollupAction action="completed"/>
</imsss:rollupRule>
```

3. Fail the aggregation if any of the children are not passed

```
<imsss:rollupRule childActivitySet="any" >
    <imsss:rollupConditions conditionCombination="any">
      <imsss:rollupCondition operator="not" condition="satisfied"/>
    </imsss:rollupConditions>
    <imsss:rollupAction action="notSatisfied"/>
</imsss:rollupRule>
```

These rules are wrapped by the *imsss:rollupRules* element in the manifest.

```
<imsss:sequencing>
   <imsss:controlModes> … </imsss:controlModes>
   <imsss:sequencingRules> …  </imsss:sequencingRules>
    <imsss:rollupRules rollupObjectiveSatisfied="true"
          rollupProgressCompletion="true" objectiveMeasureWeight="0">

   …  Rollup Rules go here

    </imsss:rollupRules>
   <imsss:objectives> …  </imsss:objectives>
<imsss:sequencing>
```

As mentioned before, rollup rules only apply to aggregations. However, all activities may participate in rollup in some way or another, even SCOs. Every activity has the opportunity to contribute to the rollup of the parent aggregation or not. This is defined in the three attributes of *imsss:rollupRules.*

- **rollupObjectiveSatisfied** - Set to "true" if activity contributes to satisfied status of parent.
- **rollupProgressCompletion** - Set to "true" if activity contributes to completion status of parent.
- **objectiveMeasureWeight** - This value is used to assist in calculating an average score for the children.

Not all activities should contribute to rollup. Consider a series of lessons followed by an assessment. You may program the course so that only the assessment contributes to the Satisfied Status, while both the lessons and the assessment must be completed for the course to be marked completed. In this case, each lesson will have `rollupObjectiveSatisfied` set to "`false`".

Best Practice: Be careful when using scores in rollups. By default, scores of the children are averaged and the resulting average score is assigned to the parent. In practice, this may not be desired. When using scores, it may be more appropriate to set `objectiveMeasureWeight` to `0.0` (doing this keeps rollups from setting a score of any kind) and use global objectives (see Tracking across SCOs using Global Objectives) when calculating and assigning a score to the parent.

11.5 Rollups vs. Global Objectives

Rollups are likely the most common way you will propagate status and scores in the activity tree. However, global objective mappings may also be used to affect the primary objective of a SCO or aggregation. This is a good idea if you need to control the status in ways that Rollups do not support. For example, instead of averaging the scores of sibling SCOs, you may wish to keep the highest or latest score. To accomplish this, a Global may be used to keep track and write the desired score to the aggregation's primary objective.

Note: Globals always take precedence over Rollups. If there is ever a conflict in the values of the statuses or scores, the Global wins.

12. Exiting SCOs and Courses

12.1 Introduction

The concept of exiting learning content is an important one. Everything that gets launched must eventually exit. There are many variations of exiting a course, that will appear to be similar from the learner's perspective, but the results are quite unique.

12.2 Examples

There are multiple applications of the word "exit," so to make it clear, consider the following use cases:

1. The learner has finished a SCO and is ready for the next activity.
2. The learner needs to "pause" in the course and return later.
3. The learner has completed all the activities in the course.

Each of these represents a way to "exit" an activity in the course. The resulting state of the course is different for each scenario.

12.3 Exiting the SCO

First, we will look at what it means to exit a SCO. When a SCO terminates, it is either with a *normal* or *suspend* exit state. If a SCO is exited normally, it means that this attempt on the SCO is completed and any re-entry into the SCO will initiate a new separate attempt. A suspended SCO retains state data from the prior session, and upon resumption of the content, the learner may be placed where he/she left off (see Bookmarking section).

To exit normally, which typically indicates some finality (not needing to resume), the following JavaScript code in the SCO may be executed:

```
doSetValue("cmi.exit","normal");
doTerminate();
```

To exit in a suspend state (the ability to resume later):

Best Practice: Make sure the learner knows what to do at all times. If you choose to just exit the SCO and remove the content, always provide prompts to the learner regarding how to continue. This may be a simple screen that displays "Select an Activity from the Table of Contents" or another appropriate message. If the course uses Control Modes, it may be appropriate to create a *continue navigation request* while setting the exit status of a SCO. See the section on Navigation for how this is done.

```
doSetValue("cmi.exit","suspend");
doTerminate();
```

From the learner's perspective, nothing happens when these JavaScript calls are made. The content remains on the screen and the learner may continue to interact with it. It is up to you as the developer, to remove the content from the screen and provide input to the learner regarding what actions to take next.

Best Practice: If a SCO is exited in the *suspend* exit state, it probably is a good idea to implement bookmarking. Check with your ISD to see what bookmarking is required in the course. If *cmi.exit* is set to suspend, additional data model elements are available to store information that may be retrieved upon reentry into the course. See Bookmarking for examples.

In many cases, the learner may exit the SCO at unexpected times. This can occur if the learner clicks the LMS navigation menu or table of contents or simply closes the browser using the window's close button. As the programmer, you need to be prepared for such cases using the browser's event handling functions. For example, if the learner closes the browser, the following code will show a confirmation dialog and suspend the SCO if closed.

```
function doOnUnload() {

    // check if we already terminated cleanly before the unload occurred.
    if (alreadyTerminated == false) {
        // make sure they meant to close the window
        event.returnValue = "Are you sure you want to exit the content?";
        event.cancelBubble = true;

        // add some cleanup or bookmarking code here as appropriate
        doSetValue("cmi.exit", "suspend");
        alreadyTerminated = true;
        doTerminate();
    }
}
```

12.4 Exiting the Course

If the SCO is exited, as described above, the course session is still active. The learner will have to select a new activity or sequencing will present a new activity to him/her. The course session is not necessarily exited if the SCO exits. A course is usually exited when the learner needs to take an extended break from the course or when the course is completed.

Note: If the element adl.nav.request (see section 8.4.3, Navigating from within Content) was set prior to terminating the SCO, the content will initiate the defined navigation request. This is the only time content will be removed upon termination.

A course is exited through the use of *exitAll* or *suspendAll* navigation requests. There is a similar relationship at the course level with *exitAll* and *suspendAll* that exists in the SCO with "*normal*" and "*suspend*" cmi.exit values. If a course receives either of these navigation requests, this will cause the course to close and the LMS will regain control.

Best Practice: It is not suggested to use *exitAll* from within the SCO. The SCO typically does not have the context to know when the course should exit completely. The sequencing request, *exitAll*, may be initiated from the imsmanifest.xml via a postConditionRule. The manifest is the best place to control such actions.

From within a SCO, when explicitly wanting to pause the course, the following code should be used:

```
doSetValue("cmi.exit","suspend");
doSetValue("adl.nav.request", "suspendAll");
doTerminate();
```

This will exit the SCO, leaving it in a suspended state and exit the course, leaving the entire course in a suspended state. At this point, the entire learning session will be removed from the screen and control will be handed back to the LMS. The course may be launched again and will resume at the suspended SCO. If the adl.nav.request element is not set, then the content will remain on the screen. It is up to you as the programmer to provide instructions to the learner on how to launch another activity.

Best Practice: Two other requests, *abandon* and *abandonAll*, will completely remove the attempt as if it never took place. It is suggested to use these with caution.

The following code can be used in the sequencing section of the SCO where a course exit is desired:

```
<imsss:sequencing>
  <imsss:sequencingRules>
    <imsss:postConditionRule>
      <imsss:ruleConditions>
        <imsss:ruleCondition condition = "satisfied"/>
      </imsss:ruleConditions>
      <imsss:ruleAction action = "exitAll"/>
    </imsss:postConditionRule>
  </imsss:sequencingRules>
</imsss:sequencing>
```

Best Practice: In many cases, it may be best to exit the course in all cases where the learner closes the content window without using the provided navigation elements. This is necessary in courses that use the Control Modes and hide the LMS navigation controls as the Table of Contents is not accessible and the learner has no option to choose a new activity.

12.5 When to Implement

As a programmer, it's important to understand the concepts of exiting and it's up to you to ensure that each exit scenario is available and accounted for per the course design. You should also assist in the development of test plans to ensure coverage of the scenarios during the testing phases of development.

12.6 How to Implement

There are four places that affect when and how content is exited:

1. The LMS Navigation UI
2. The LMS table of contents
3. Programming JavaScript calls inside the SCO
4. Sequencing post-condition rules

12.6.1 LMS-provided Navigation UI

The learner may select an action from the navigation menu provided natively by the LMS. This may be a Next or Previous button or may be one of the Exit buttons for the course. If these options are available to the learner, you have very little control over when these actions are initiated. The content needs to be programmed to capture exit events from the learner and handle them appropriately.

Best Practice: If the design requires some level of control over when the learner exits a SCO and moves to the next SCO, the LMS navigation UI should be customized as discussed in the Navigation section.

12.6.2 LMS Table of Contents

This is very similar to the navigation interface provided by the LMS. If the learner clicks on an activity in the table of contents, the current activity is exited and a new activity is

Best Practice: If the design requires more control over when the learner selects activities to experience, then enabling the table of contents may not be appropriate. See section on Control Modes for additional options.

selected for the learner. Content will need to be handled in a similar manner as above.

12.6.3 Exiting from within Content

When a SCO is exited with no additional navigation action, control remains with the learner. The learner will need to select the next activity from the table of contents (if available). If a navigation request is initiated after exiting the SCO or if a course is exited, control is returned to the LMS. The LMS will either select a new activity (based on sequencing rules) to launch or the current session will be terminated.

12.6.4 Exiting via Sequencing Rules

As mentioned above, it's probably not a good idea to exit the course (using an *exitAll* navigation request) from within a SCO. If a learner finishes the course and has experienced all the content available to him/her per the course's design, then it's possible for the attempt on the course to be finalized through the use of sequencing. This is done in two ways:

Continue Past the Last Available SCO

If a continue request (e.g., see the Navigation section in this document) is made that causes the course to sequence past the last available SCO, the course is considered to have "walked off the tree." The result of this action is to effectively finalize the current attempt of the course and turn control over to the LMS.

Initiate an exitAll Sequencing request from a Post-condition Rule

A post-condition action can be associated with an activity that will cause the course to exit and finish based on a certain condition. In the following example, the course will exit if the activity is satisfied. This sequencing code may be placed in the sequencing section of any SCO or aggregation.

```
<imsss:sequencingRules>
  <imsss:postConditionRule>
    <imsss:ruleConditions conditionCombination="all">
      <imsss:ruleCondition condition="satisfied" />
    </imsss:ruleConditions>
    <imsss:ruleAction action="exitAll" />
  </imsss:postConditionRule>
</imsss:sequencingRules>
```

Note: Where does an exit condition fit into all this? An exit condition rule may be applied at the cluster level to force an *exit* action on the cluster. Note that this is different than actually exiting or leaving a SCO or cluster. This is a special action in sequencing that will trigger the execution of post-condition rules in the cluster. In a cluster, these rules are executed only if a child explicitly executes an *exitParent* action in its own post condition rules or if the cluster's Exit Condition Rule executes an *exit* action. The following code will cause a cluster's post-condition rules to be evaluated if the cluster is satisfied.

```
<imsss:sequencingRules>
  <imsss:exitConditionRule>
    <imsss:ruleConditions>
      <imsss:ruleCondition condition="satisfied"/>
    </imsss:ruleConditions>
    <imsss:ruleAction action="exit"/>
  </imsss:exitConditionRule>
</imsss:sequencingRules>
```

Resources, Tools, & Development Support

13. ADL SCORM Resources Overview

13.1 Background

ADL does not provide or recommend tools to build content. However, there are a few ADL applications and documents that can assist in the development process. Located at http://www.adlnet.gov/capabilities/scorm#tab-learn, they are:

- SCORM 2004 4th Edition Document Suite (CAM, SN, & RTE SCORM Books)
- SCORM 2004 4th Edition Sample Run-Time Environment (SRTE)
- SCORM 2004 4th Edition Test Suite (TS)
- ADL SCORM 2004 4th Edition Content Examples

13.2 SCORM 2004 4th Edition Document Suite

13.2.1 Background

The official documentation of SCORM can be found in three books. They are commonly called *The SCORM Books*. These books contain detailed information about the specifications included in SCORM. Here we will break them down so you know where to go for what information.

13.2.2 Content Aggregation Model (CAM) Book

The introduction of the CAM book (see CAM 1.1) says:

> "The SCORM Content Aggregation Model (CAM) book describes the components used in a learning experience, how to package those components for exchange from system to system, how to describe those components to enable search and discovery and how to define sequencing information for the components. The SCORM CAM promotes the consistent storage, labeling, packaging, exchange and discovery of learning content."

In plain English, this book contains information that describes:

- High level information on content packaging and organization
- Specific details on the syntax of the Manifest File
- An overview of Metadata, including Learning Object Metadata (LOM) details
- Best Practices and Practical Guidelines

13.2.3 Sequencing and Navigation (SN) Book

The introduction to the SN book states:

> "The SCORM SN book describes how SCORM-conformant content may be delivered to learners through a set of learner- or system-initiated navigation events. The branching and flow of that content may be described by a predefined set of activities."

This book contains conceptual information related to:

- Sequencing Definitions and Behaviors
- Navigation Controls and Data model

13.2.4 Run-Time Environment (RTE) Book

The introduction to the RTE book states:

> "The SCORM RTE book describes the learning management system (LMS) requirements in managing the run-time environment (i.e., content launch process, standardized communication between content and LMSs and standardized data model elements used for passing information relevant to the learner's experience with the content). The RTE book also covers the requirements of Sharable Content Objects (SCOs) and their use of a common application programming interface (API) and the SCORM Run-Time Environment Data Model."

This book covers:

- SCORM API
- CMI Data Model Overview

13.3 SCORM 2004 4th Edition Sample Run-Time Environment (SRTE)

13.3.1 Background

The SCORM 2004 4th Edition Sample Run-Time Environment (SRTE) Version 1.1.1 provides a working example of the Run-Time Environment described in SCORM 2004 4th Edition. In simple terms, the SRTE functions as a sample player for your content. The intent is to provide a stable environment to test content to make sure it runs as expected. The SRTE can be found at http://www.adlnet.gov/capabilities/scorm#tab-learn.

13.3.2 When to Use the SRTE

Use the SRTE for your testing process during content development. The SRTE will allow you to test:

- Content Import

The SRTE will do a validation on your content package before importing it to ensure conformance. For more detailed testing, use the SCORM 2004 4th Edition Test Suite (TS), described below.

- Content Delivery

The SRTE will allow you to launch your content and see how it will appear when running in an LMS.

Note: All LMSes will provide a similar UI, but the look and feel will vary. The SRTE will give you an idea and will also allow you to test your content in a browser environment.

- SCORM API and Data Model Usage

All the SCORM 2004 API features and the CMI Data Model are available in the SRTE. You can fully test this functionality prior to LMS deployment.

- Sequencing and Navigation

Sequencing is one of the more complex components of an LMS implementation. If you are unfamiliar with your LMS's sequencing implementation or are trying to debug a sequencing related issue, it's always good to go back to the SRTE and ensure that it functions there first.

Best Practice: In some cases, even an LMS claiming to be conformant will have incorrect behaviors regarding sequencing. Using the SRTE as a comparison base is a good idea, so you can assist the vendor in correcting conformance issues.

13.4 SCORM 2004 4th Edition Test Suite (TS)

13.4.1 Background

The only way to ensure your content is SCORM 2004 4th Edition conformant is to use the ADL SCORM 2004 4th Edition Test Suite, here referred to as the TS.

13.4.2 When to Use the TS

The TS provides five tests, four of which can be used by you as a content developer.

- **Learning Management System (LMS) Conformance Test**

This test is used by LMS vendors to test their SCORM implementations. You can ignore this test.

- **Content Package Conformance Test**

This test will check your content package for conformance. It will check the manifest file (similar to Manifest Utility), linked metadata files, and will launch the SCO RTE test as well.

- **Sharable Content Object (SCO) Run-Time Environment (RTE) Conformance Utility Test**

This test will allow you to launch all the SCOs in the manifest file and monitor the API traffic between your content and the SCORM API. It will ensure that at a minimum the SCO initializes and terminates correctly and that there are no conformance errors in the RTE programming.

- **Manifest Utility Test**

This test will simply check the manifest file for conformance and check that the files in the package match those listed in the resources.

- **Checksum Utility Test**

This is a handy utility to verify that a prior test log generated by the TS is valid for your current content package. It will make sure that no files in the content package have changed since that log was generated.

13.5 ADL SCORM 2004 4th Edition Content Examples

13.5.1 Background

ADL provides six content packages containing functional examples of SCORM 2004 implementation strategies in addition to offering sound instruction on SCORM 2004 4th Edition content development. (See: http://www.adlnet.gov/capabilities/scorm#tab-learn)

13.5.2 Content Examples

- **Manifest Basics Content Example (MBCE)**

The MBCE serves to show the basic concepts and components of a content package manifest in SCORM.

- **Bookmarking Example (BKME)**

The BKME shows the concept of bookmarking, the rules and components needed to successfully use it, as well as implementation strategies to allow creation of content that can be resumed in its most recent state.

- **Plug-In Technologies Content Example (PITE)**

The PITE shows how to implement SCORM 2004 web-based solutions beyond that of JavaScript by looking at strategies of using SCORM 2004 with both Adobe® Flash® and Adobe® Director®.

- **The Sequencing Essentials Content Example (SECE)**

The SECE provides sequencing information and examples in preparation for or reference use in development of SCORM 2004 content.

- **The Data Model Content Example (DMCE)**

The DMCE provides data model element information and examples in preparation for or reference use in development of SCORM 2004 content.

- **The Multiple Sequencing Content Example (MSCE)**

The MSCE provides a common set of content with different sequencing implementations to fit multiple pedagogical approaches.

Cookbook

In this section of the guide, we will address common questions about SCORM that have surfaced over the years. We have included examples, tips, tricks, and best practices based on expert input and experience.

14. Bookmarking

14.1 Background

Bookmarking is the common term used for allowing the learner to take a break and then return to where they left off in the content. SCORM 2004 does not use the term *Bookmarking*, but provides multiple ways to accomplish this.

14.2 How to Implement

14.2.1 Save the State

SCORM 2004 4th Edition provides two ways to save content state that can be accessed when the learner resumes. These elements are simply storage areas for text that may be used for bookmarking. No bookmarking occurs automatically. As the programmer, it is your responsibility to use this data to initialize the content in the SCO at the bookmarked location.

cmi.location

The CMI Data Model has a *location* element (see RTE 4.2.14) that can be used to store a string. It can hold 1000 characters.

Example:

```
// to set the data
doSetValue("cmi.location", "some data that you want to store");

// to retrieve it later …
var bookmark = doGetValue("cmi.location");

// The programmer should use this bookmark variable to initialize the SCO
// and put the learner back where they left off. Nothing automatically happens
// here.
```

cmi.suspend_data

If 1000 characters are not enough, the CMI Data Model has an element to store the suspended state of a SCO (see RTE 4.2.23). This element can also be used to store a string. It can hold 64000 characters.

Example:

```
// to set the data
doSetValue("cmi.suspend_data",
           "some more data that you want to store");

// to retrieve it later …
var bookmark = doGetValue("cmi.suspend_data");

// The programmer should use this bookmark variable to initialize the SCO
// and put the learner back where they left off. Nothing automatically happens
// here.
```

14.2.2 Suspend the Content

For bookmarking, content must be exited in a suspended state (see Rollups). To suspend only the current SCO, two JavaScript lines must be added:

```
doSetValue("cmi.exit", "suspend");
doTerminate();
```

At this point, you will need to provide the learner with an option to choose another activity.

Typically, when the learner needs to suspend for a period of time, control should be returned to the LMS. This is accomplished through a Suspend All navigation request (see Navigation). This can be done by using the LMS-provided UI or the following JavaScript code within the content:

```
doSetValue("cmi.exit", "suspend");
doSetValue("adl.nav.request", "suspendAll");
doTerminate();
```

14.3 Learner Option

In some cases, you will want to give the learner the option to use the bookmark to resume or to start the activity over from the beginning. Figure 14.1 shows an example of how you may prompt the learner when resuming a suspended SCO.

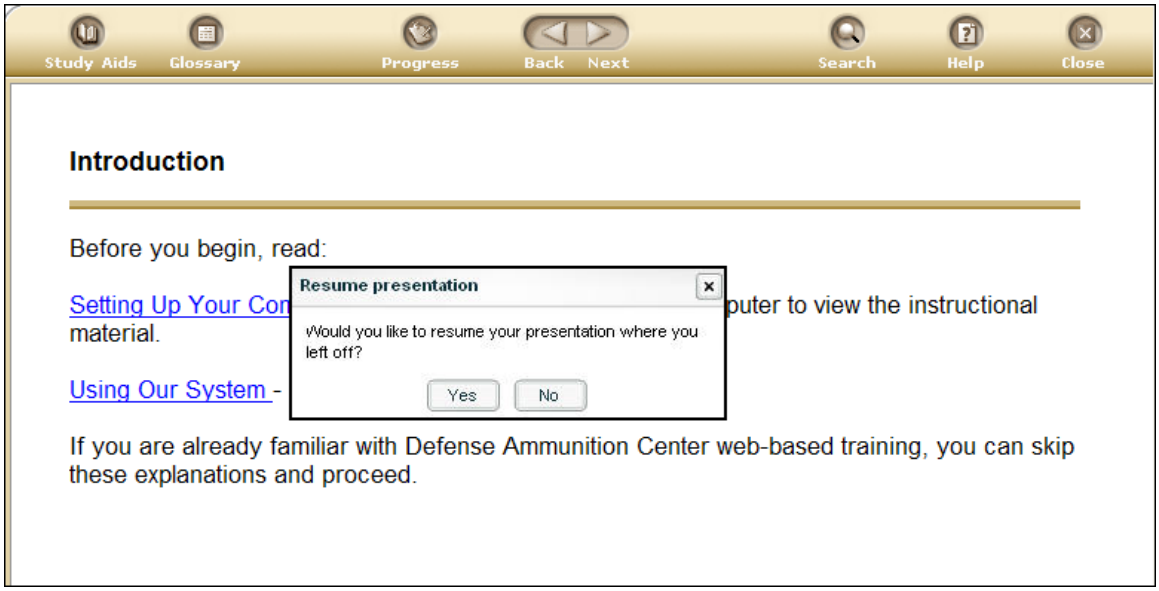


Figure 14.1 Example Use of *cmi.location* Data Model Element in a SCO

15. Prerequisites

15.1 Background

A very common design pattern is that of a prerequisite. This is where the availability of one activity is dependent on some external condition, typically the completion or satisfaction of a prior activity.

For example, Figure 15.1 shows a flowchart with a series of lessons followed by an assessment. The design dictates that the lessons be completed before the assessment is accessible.

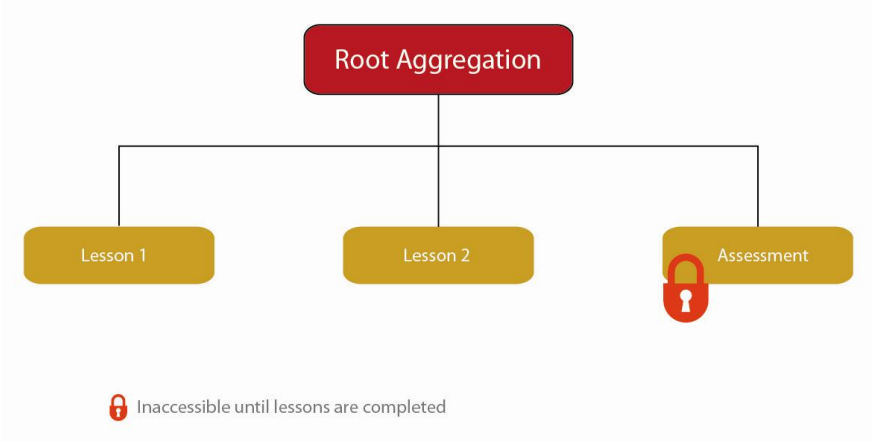


Figure 15.1 Flowchart of two lessons followed by a locked assessment.

15.2 How to Implement

The steps to implement this are listed below and are described in detail in this section:

1. Create an aggregation (cluster) for the lessons
2. Add Rollup Rules to aggregation
3. Map aggregation's primary objective to a shared global
4. Create Pre-Condition rule on the assessment

15.2.1 Create an Aggregation (Cluster) for the Lessons

In order to track the completion of all the lessons, the lesson SCOs need to be organized in an aggregation, or cluster. This will allow Rollup Rules to be created to assist in tracking them as a collective.

```
<item identifier="CLUSTER-ONE" isvisible="true" >
```

```
    <title>Lesson Aggregation</title>
    <item identifier="LESSON1" identifierref="RES-SCO1"
          isvisible="true">
      <title>Child 1</title>
    </item>
    <item identifier="LESSON2" identifierref="RES-SCO2"
          isvisible="true">
      <title>Child 2</title>
    </item>
    <item identifier="ASSESSMENT" identifierref="RES-SCO3"
          isvisible="true">
      <title>Child 3</title>

      <!-- Pre-condition sequencing rules go here,
      see 15.2.4 Create Pre-Condition Rule on Assessment -->

    </item>
    <imsss:sequencing>
      <imsss:controlMode flow="true" choice="true"/>

        <!-- Rollups go here,
        see section 15.2.2 Implement Rollup Rules for the Aggregation -->
        <!-- Objectives go here,
        see 15.2.3 Map Aggregation's Primary Objective to a Shared Global -->

    </imsss:sequencing>
  </item>
```

15.2.2 Implement Rollup Rules for the Aggregation

The Rollup Rules for the aggregation are shown here. The logic conditions used are:

- "If any lesson is NOT COMPLETED" set the aggregation to incomplete.
- "If All lessons are COMPLETED" set the aggregation to COMPLETED.

```
<!--
Two important rules:
- If any are incomplete, the cluster is incomplete.
- If all are completed, the cluster is complete.
-->
<imsss:rollupRules rollupObjectiveSatisfied="true"
                   rollupProgressCompletion="true">
  <imsss:rollupRule childActivitySet="any">
    <imsss:rollupConditions conditionCombination="any">
      <imsss:rollupCondition operator="not" condition="completed"/>
    <imsss:rollupConditions>
    <imsss:rollupAction action="incomplete"/>
  </imsss:rollupRule>
  <imsss:rollupRule childActivitySet="all">
    <imsss:rollupConditions conditionCombination="any">
      <imsss:rollupCondition condition="completed"/>
    </imsss:rollupConditions>
    <imsss:rollupAction action="complete"/>
  </imsss:rollupRule>
</imsss:rollupRules>
```

15.2.3 Map Aggregation's Primary Objective to a Shared Global

In order to track the completion status of the lesson aggregation, a shared global objective must be used. This shared global is mapped to the primary objective of the aggregation. In this example, we are writing from the primary objective to the satisfied and completion status of the shared global named *obj-global-lessons*. This global will always have the current Completion Status of the cluster. We will use this later to create the prerequisite condition.

```
<imsss:objectives>
<!—
Map that global to the primary of the aggregation so it gets the core status.
-->

  <imsss:primaryObjective objectiveID="obj-primary" satisfiedByMeasure="false">
    <imsss:mapInfo targetObjectiveID="obj-global-lessons"
                   writeSatisfiedStatus="true"/>
  </imsss:primaryObjective>
</imsss:objectives>

<!--
Use the 4th Ed adlseq:objectives to capture if this aggregation is completed
in a global named obj-global-lessons.
-->

<adlseq:objectives>
  <adlseq:objective objectiveID = "obj-primary">
    <adlseq:mapInfo targetObjectiveID = "obj-global-lessons"
                    writeCompletionStatus="true" />
  </adlseq:objective>
</adlseq:objectives>
```

15.2.4 Create Pre-Condition Rule on Assessment

To create the prerequisite, a pre-condition sequencing rule is used (see Sequencing section). The following code is the sequencing used in the assessment. You will map the shared global from 1.2.3 above to a local objective *obj-prereqs,* and create an action to disable the assessment while *obj-prereqs* is either *unknown* or *incomplete.*

```
<imsss:sequencing>
  <imsss:sequencingRules>
    <!--
       You can now sequence off the completed status of the global.
       You have to account for the "unknown" state of completion, so 2
       conditions are needed
    -->
    <imsss:preConditionRule>
      <imsss:ruleConditions conditionCombination="any">
        <imsss:ruleCondition operator="not" condition="completed"
                             referencedObjective="obj-prereqs" />
        <imsss:ruleCondition operator="not" condition="activityProgressKnown"
                             referencedObjective="obj-prereqs" />
      </imsss:ruleConditions>
      <imsss:ruleAction action="disabled" />
    </imsss:preConditionRule>
  </imsss:sequencingRules>
```

```
    <imsss:rollupRules rollupObjectiveSatisfied="true"
                       rollupProgressCompletion="true"  />
    <imsss:objectives>
      <imsss:primaryObjective objectiveID="obj-primary"
                              satisfiedByMeasure="false"/>
      <imsss:objective objectiveID="obj-prereqs" satisfiedByMeasure="false">
        <imsss:mapInfo targetObjectiveID="obj-global-lessons"
                       readSatisfiedStatus="true"/>
      </imsss:objective>
    </imsss:objectives>
    <imsss:deliveryControls objectiveSetByContent = "true"/>
    <adlseq:objectives>
      <!--
        This lets you read the global's completion status and bring it into
        scope
      -->
      <adlseq:objective objectiveID = "obj-prereqs">
        <adlseq:mapInfo targetObjectiveID = "obj-global-lessons"
                        readCompletionStatus="true" />
      </adlseq:objective>
    </adlseq:objectives>
  </imsss:sequencing>
```

16. Assessments

16.1 Introduction

An assessment, otherwise known as a test, is a common type of content. It is implemented as a normal SCO. However, SCORM provides some features that can assist in the tracking and reporting of the learner's experience in the assessment. In this section, we will look at the CMI Data Model of *cmi.success_status, cmi.score, cmi.interactions* and how they may be utilized in assessments.

16.2 When to Implement

The tracking requirements for an assessment will vary based on the design. These requirements need to be discussed with your designers (ISDs). In some cases, you may only need to mark the assessment as passed or failed. In other cases, you may also need to calculate a numeric score and store this in the LMS as well. In yet other instances, you may have to capture and store in the LMS detailed information about each assessed item.

16.3 Examples

SCORM provides some functionality that is commonly used in assessments and will help you implement almost any design your ISD provides. An assessment can be a simple set of questions (multiple-choice, true/false, fill in the blank, etc.), or it can be a complex scenario with detailed step-by-step processes that must be performed in a certain order. SCORM does not impose any restrictions on assessments. An assessment in SCORM is treated just like any other type of SCO.

16.4 How to Implement

All tracking in SCORM is done using the CMI Data Model.

16.4.1 Pass/Fail and Scoring

Most assessments are graded and given a result of *passed* or *failed*. This value is calculated by the programming logic in the course and the resulting value is stored in the LMS as follows:

```
// cmi.success_status is either passed or failed
doSetValue("cmi.success_status","passed");
```

Many assessments are also given a numeric score. The calculated numeric score is stored in the LMS using the *cmi.score* object:

```
// represents a score of 75%
doSetValue("cmi.score.scaled","0.75");
```

For more details regarding SCORM and scoring, refer to the section on Status and Scoring.

16.4.2 Interactions

In some assessments, detailed information about each assessed item is also captured and stored. To track details about each tested item in an assessment, the data model element *cmi.interactions* is used (see RTE 4.2.9). Interactions allow a SCO to send data to the Learning Management System (LMS) about a learner's performance in an interoperable way. It provides a detailed model for designers and programmers to collect metrics about learner responses or performance within a SCO, particularly detailed data related to performance on assessments such as expected correct response, the learner's response, duration taken to respond, etc.

The *cmi.interactions* data model element is an array type object consisting of many interactions. A single interaction describes a tested item. An interaction is represented by dot notation similar to other cmi data model elements. Refer to the section on CMI Data Model for details on this syntax.

The most common elements used in the *cmi.interaction* object are shown below. See RTE Table 4.2.9a for details of the syntax used in creating an interaction.

- **id** - The question identifier. This is used to associate the question to a database or master list of questions.
- **description** - A description of the interaction. This might be the question presented or a description of the task given to the learner.
- **type** - Type of question, e.g. multiple-choice, true/false, matching, etc.
- **timestamp** – The time when this item was presented to the learner
- **correct_responses** - Defines an array of correct responses to be presented. The array is a list of patterns that correspond to the type of interaction.
- **learner_response** – What the learner actually answered
- **result** - Whether the learner's response was correct or not
- **latency** – How long it took the learner to respond

The interactions are a collection of information stored in arrays. The cmi data-model uses a zero-based index position (n) in the dot-notation to separate the data. For example, if there were ten assessment items, the identifier of the third one would be accessed like this:

```
cmi.interactions.2.id
```

Here is an example of a multiple-choice question and how to represent it using interactions:

Which of the following cities is in Texas?

A - Los Angeles
B - Santa Fe
C - Austin
D - New York City

Using interactions, the following code is required to be implemented in the SCO:

```
// Find an array index to use for the new interaction.  This is
// done by checking how many exist and using that as the next
// available index in the array.
var numInts  = doGetValue("cmi.interactions._count");

// Create the new one. The id must be a valid Uniform Resource
// Identifier (URI). In general, it is a short string (no spaces)
// that can be used to identify the interaction in an external
// list.  A list of all the interaction elements and their types
// can be found in RTE table 4.2.9a
var id = "example-question-1";
doSetValue("cmi.interactions." + numInts + ".id", id);

// Set the type of interaction.  The options include:
// true-false, choice, fill-in, long-fill-in, likert, matching,
// performance sequencing, numeric, other (see RTE table 4.2.9a)
doSetValue("cmi.interactions." + numInts + ".type", "choice");

// description is typically the question asked or task
// description
doSetValue("cmi.interactions." + numInts + ".description",
           "Which of the following cities are in Texas?");

// The correct responses array contains a list of possible
// correct answers. Each correct answer has a pattern specific to
// the type defined above. These patterns are defined in
// RTE table 4.2.9a. The simplest example is shown below:  A
// multiple choice response with a single correct answer.
doSetValue("cmi.interactions." + numInts + ".correct_responses.0.pattern",
           "Austin");

// When the learner submits their answer, you (the programmer)
// must capture this response and store it in the
// learner_response field of the interaction.
doSetValue("cmi.interactions." + numInts + ".learner_response",
           "SantaFe");

// An interaction also stores the result.  The values may be:
// correct, incorrect, unanticipated, neutral, or a real number.  The
// programming logic of the SCO will determine
// the result of the learner's answer and store it here.
doSetValue("cmi.interactions." + numInts + ".result",
           "incorrect");
```

This example is then repeated for each tested item in the assessment.

Note: Interactions may be used to do detailed item-level analysis of your assessments. Most LMSs provide some method of querying and reporting interaction data for a course. However, this functionality is outside of SCORM and can vary widely from one LMS to another. It's important to understand how your LMS reports runtime data for courses and how to best utilize this to meet the analysis needs of your design.

17. The Menu SCO

17.1 Background

As mentioned in the section on Navigation, the LMS will provide some rudimentary methods for the learner to navigate the activity tree of a course. The Table of Contents is a requirement of SCORM and is useful in many situations. However, it's not customizable and has a few notable shortcomings:

- Control Modes are not dynamic.
  You can set an aggregation to use Control Mode *choice* or not. This can't be changed dynamically after importing into the LMS.

- Table of Contents does not provide context to the learner.
  The LMS does not know the context of your content and therefore cannot provide the learner with prompts that might be necessary to help them make a good choice in the table of contents.

- Table of Contents UI is not customizable.
  The LMS-provided Table of Contents is typically just an outline structure representing the activity tree. For your content, you might wish to provide something a bit more engaging or graphically stimulating. This is currently not possible.

All these issues keep the Table of Contents from being a viable navigation element in some cases. There is a design pattern, which we will call the Menu SCO, which may be used to help.

17.2 How to Implement

The steps to implement this are listed here and described in detail in the sections that follow.

- Create a SCO that contains a nice "menu"
- Use Shared Globals to track status of menu items.
- Program menu to use global objectives
- Program menu to issue Navigation Requests
- Add navigation to show menu after each item

17.3 Create a SCO that Contains a Nice "Menu"

Get creative. This can be anything you want. The key here is to add value. This is your chance to add context to navigation and give the learner the information he/she needs to experience your course effectively. It should contain some thought and design; otherwise, it's not much better than the standard Table of Contents. Your designer should provide you with input on what the navigational map should be.

Some examples may be:

- A map of the world, where each continent is selectable
- History timeline, where dates are selectable
- Images that show progression, such as how plants or animals grow

Figure 16.1 shows an example menu SCO implementation. An interactive timeline is presented to the learner. As the learner moves his mouse over the images, a brief description of the material is presented. To experience the training related to the Persian Gulf War, the learner may click on the image associated with 1990 and SCORM 2004 Sequencing & Navigation will present this training.

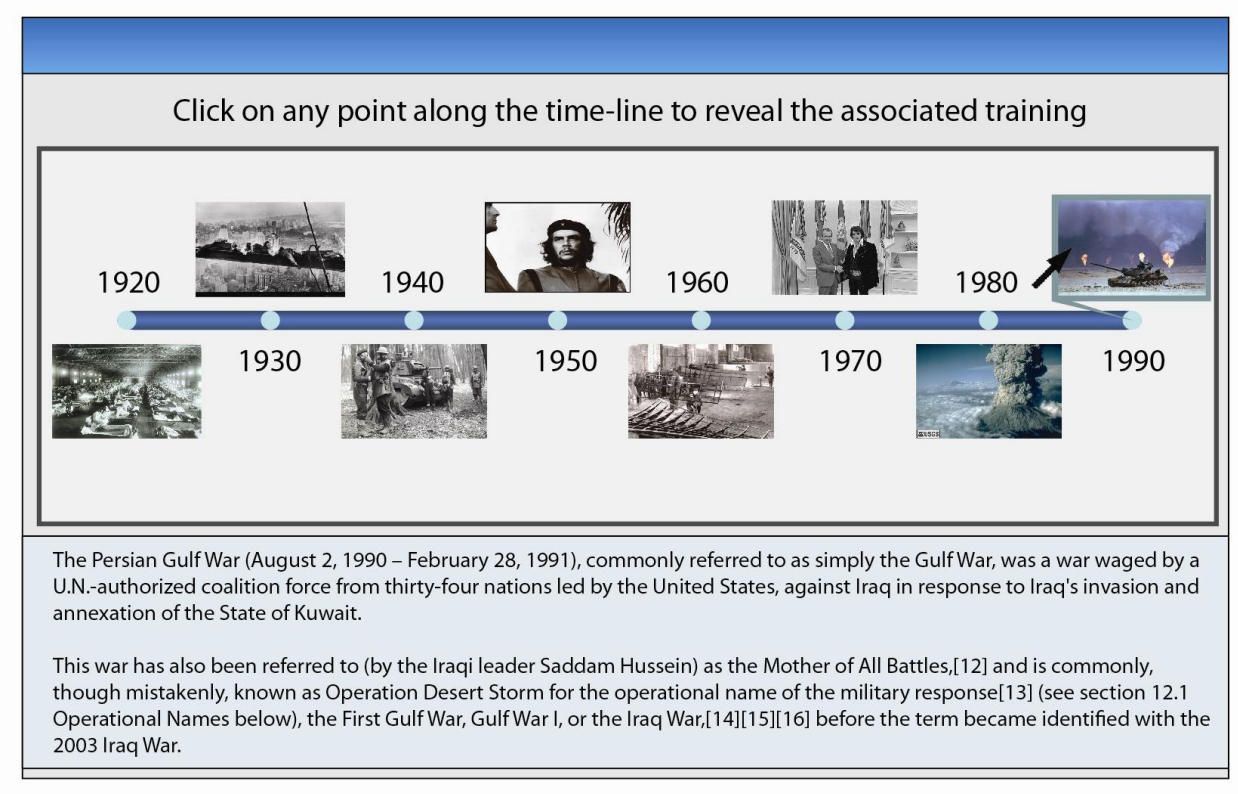


Figure 16.1 Timeline as menu – 1990 is selected in this example.

17.3.1 Use Shared Globals to Track Menu Items

In order for the Menu SCO to track the progress of the course's activities, shared global objectives must be used. Using the examples in the section on global objectives (see Tracking across SCOs using Global Objectives), define global objectives for each menu item in the Menu SCO. These global objectives will also need to be defined in the associated activities' objectives section. In the example above, each year in the timeline will have an associated global objective.

17.3.2 Program Menu and Content to Use Global Objectives

Defining the global objectives in the manifest file for the Menu SCO is not enough. You must actually program the content to utilize this information. For example, reading the information from global objectives will allow you to do things like:

- Display which activities have been completed
- Display the passed/failed status for each module
- Display a status bar showing completion progress for each module

Again, this is a time to work with your ISD to determine what needs to be shown. It's important to choose features that will be engaging and add value.

You also have to make sure your content updates the global objectives. If the objectives are mapped to the content's primary objectives, then ensure the content is updating the necessary CMI Data Model values that will update the global. (See CMI Data Model and Globals.)

17.3.3 Program Menu to Issue Navigation Requests

To actually launch the content, the Menu SCO will need to issue Jump navigation requests (see Navigation section). This is a new navigation request in SCORM 2004 4th Edition and allows a SCO to explicitly target another SCO for navigation purposes. In our timeline example above, JavaScript code should be implemented to perform these requests. The *identifier* attribute found in the manifest file for the *<item>* element associated with the targeted activity is what the navigation request references. For example, the following is a sample manifest file entry for our SCO:

```
<item identifier="SCO-PERSIAN-GULF-1990" identifierref="RES-PERSIAN-GULF-1990">
    <title>Persian Gulf War</title>
</item>
```

To target this SCO from our Menu SCO, the following JavaScript code is implemented within the Menu SCO HTML file:

```
doSetValue("adl.nav.request", "{target=SCO-PERSIAN-GULF-1990}jump"};
doTerminate();
```

The LMS will immediately terminate the Menu SCO and deliver the content for the Persian Gulf War.

17.3.4 Add Navigation to Show Menu after Each Item

A key part of using the Menu SCO design is that the menu must be displayed at the appropriate times. This will depend on design, but a common pattern is to display the Menu after exiting each activity. This can easily be accomplished using a Jump request similar to the one explained above to target the Menu SCO. The lessons can be configured upon launch using CMI Launch Data (see CMI Data Model) to know the SCO identifier of the Menu SCO.

The value of the menu SCO may be passed from the manifest file by using the adlcp:dataFromLMS element as shown in this example:

```
<item identifier="SCO1" identifierref="RESOURCE1">
    <title>Lesson 1</title>
    <adlcp:dataFromLMS>NAV-MENU</adlcp:dataFromLMS>
</item>
```

And in JavaScript:

```
var menuId = doGetValue("cmi.launch_data");
// menuId will be "NAV-MENU" here

// check the return value. If no menu SCO is provided, then no
// navigation request is needed
if (menuId != "") {
    doSetValue("adl.nav.request", "{target=" + menuId + "}jump"};
}
doTerminate();
```

17.4 Impact on Reuse

The Menu SCO is a great example of designing for reuse. For a SCO to be standalone and easily reused or repurposed, it should not have to know much about the other SCOs in the course. The Menu SCO in this example is separated from the learning content and it is the only SCO that needs to use information from other SCOs. The sequencing that displays the Menu SCO is in the manifest file and is relevant only to this activity tree. The content SCOs themselves are not aware of the Menu SCO and can be freely reused in any context.

18. Sequencing Collections

18.1 Background

Sequencing can be complex and XML can be very verbose. This combination can make for rather lengthy manifest files. Many times the patterns in sequencing will be repeated throughout a course. When these patterns emerge, Sequencing Collections can come in handy to reduce the size and redundancy of the XML. This makes the manifest more readable and maintainable as functionality is encapsulated in one location.

18.2 How to Implement

Implementing sequencing collections is straightforward. First identify the repeated blocks of sequencing. Take for example this code, which, if satisfied, issues an *exitParent* action in a post-condition rule.

```
<imsss:sequencing>
  <imsss:sequencingRules>
    <imsss:postConditionRule>
      <imsss:ruleConditions conditionCombination="any">
        <imsss:ruleCondition condition="satisfied" />
      </imsss:ruleConditions>
      <imsss:ruleAction action="exitParent" />
    </imsss:postConditionRule>
  </imsss:sequencingRules>
  <imsss:rollupRules rollupObjectiveSatisfied="true"
                     rollupProgressCompletion="true" />
  <imsss:objectives>
    <imsss:primaryObjective objectiveID="obj-primary"
                            satisfiedByMeasure="false">
      <imsss:mapInfo targetObjectiveID="g-obj-item-one-1"
                     writeSatisfiedStatus="true"/>
    </imsss:primaryObjective>
  </imsss:objectives>
  <imsss:deliveryControls objectiveSetByContent = "true"
                          completionSetByContent="true"/>
</imsss:sequencing>
```

Imagine having a series of twenty SCOs with this same flow pattern. There would be over 300 lines of repeated XML for the sequencing. To solve this, we create a *sequencingCollection* element that encapsulates the repeated components of the XML.

```
<imsss:sequencingCollection>
  <imsss:sequencing ID="lesson_seq_rules">
    <!-- exit parent when terminating, if satisfied -->
     <imsss:sequencingRules>
       <imsss:postConditionRule>
         <imsss:ruleConditions conditionCombination="any">
           <imsss:ruleCondition condition="satisfied" />
         </imsss:ruleConditions>
```

```
            <imsss:ruleAction action="exitParent" />
          </imsss:postConditionRule>
        </imsss:sequencingRules>

        <!-- Content counts towards rollup Success and Completion -->
        <imsss:rollupRules rollupObjectiveSatisfied="true"
                           rollupProgressCompletion="true" />

        <!-- Note that the objectives are not included here! -->

        <imsss:deliveryControls completionSetByContent="true"
                                objectiveSetByContent="true"/>

    </imsss:sequencing>
</imsss:sequencingCollection>
```

This XML for the collection is placed at the bottom of the manifest file, just before the closing manifest tag, `</manifest>`.

Note: As noted in the XML comment, the *objectives* element is not included. The collection only contains repeated bits of the XML. Any additional elements and rules will be left in the original *sequencing* section and will be merged at runtime.

Going back to our original sequencing sections, we can replace them with this code:

```
<imsss:sequencing IDRef="lesson_seq_rules">
  <!-- the objectives element is unique per activity, therefore it is
       not abstracted out into the collection -->
  <imsss:objectives>
    <imsss:primaryObjective objectiveID="obj-primary"
                            satisfiedByMeasure="false">
      <imsss:mapInfo targetObjectiveID="g-obj-item-one-1"
                     writeSatisfiedStatus="true"/>
    </imsss:primaryObjective>
  </imsss:objectives>
</imsss:sequencing>
```

In our example, we have taken a seventeen-line segment of XML and reduced it to seven lines. Doesn't seem like much, but this was a simple example and it adds up the more times it's repeated. If you have ten SCOs like this, the savings is 100 lines. But the bigger win is that there is now only one place to edit to alter the behavior across the course. There is much less room for mistakes.

Note: If you are using a tool to produce your XML, it may or may not support collections. You will have to refer to the specific documentation of the tool to determine if this is a viable option for you.

Glossary of SCORM Terminology

Accessible: Accessible content can be loaded and accessed when needed to meet training and education requirements.

Adaptable: Adaptable content can be customized for individual learners and organizations as needed.

Advanced Distributed Learning (ADL): An evolving, outcomes-focused approach to education, training, and performance support that blends standards-based distributed learning models emphasizing reusable content objects, content and learning management systems, performance support systems/devices, web applications services, and connectivity.

Advanced Distributed Learning Registry (ADL-R): The ADL Registry is the Department of Defense (DOD) central registry for content repositories and SCORM content packages. The ADL Registry portal at http://adlregistry.adlnet.gov/ is where DoD affiliated persons, as instructed by *DoDI 1322.26*, submit and search for SCORM-conformant content.

Aggregation: Aggregations are used to group related content so that it can be delivered to learners in the manner you prescribe. Sequencing rules allow you to prescribe the behaviors and functionality of the content within the aggregation as well as how the aggregation relates to other SCOs within the same root aggregation. In SCORM 2004, aggregations are also referred to as clusters.

Application Programming Interface (API): The SCORM API is a standardized method for a sharable content object (SCO) to communicate with the learning management system (LMS) when a learner is interacting with a SCO. There is a specific set of information the SCO can set or retrieve. For example, it can retrieve information, such as a student name, or a set of values, such as a score.

API Wrapper: A script commonly used in SCORM development to simplify how a programmer interacts with an instance of the SCORM API. The script will contain wrapper functions that find the API instance and encapsulate commonly used functionality.

Asset: Assets are electronic representations of media, text, images, sounds, web pages and other pieces of data that can be delivered to a Web client. They do not communicate with the LMS directly. Assets, like the sharable content objects (SCOs) in which they appear, are highly reusable. In order to be reused, assets are described using metadata so that they are both searchable and discoverable in online content repositories.

Certification or Certified: "Certification" indicates that materials have been tested by an independent third party to assess conformance with the guidelines established in SCORM. "Certification" indicates a successful testing by the Conformance Test Suite. All "certified" products are "conformant."

Choice: A control mode that defines if the learner may select an activity of this cluster through a choice navigation request.

Cluster (synonym for Aggregation)

Completion Status: The status used to track if an activity is attempted and if it is completed or incomplete.

Compliance or Compliant: A product is compliant when tested to ensure it performs according to applicable guidelines, instructions, policy, or law. The SCORM test suite is designed to rigorously test inputs, processes, and outputs.

Conformance or Conformant: A product or service is conformant when it adheres to technical specifications, guidelines, recommendations, or best practices to identify the correctness, completeness, and quality of developed product or service. Test assertions are achieved by inspecting results focused on reliability, stability, portability, maintainability, and usability. No form of testing is used other than evaluating actual results against expected results.

Content Package: The content package contains everything needed to deliver the course, module, lesson, etc. to the learner via the LMS. A SCORM content package contains two principal entities: (1) a manifest file that lists all of the resources or assets you want to include in the package, the content structure you created (called the organization), the sequencing rules, and all of the metadata for the SCOs, the LOs, and the package itself; (2) all of the physical SCO and asset files for the content. It ends up as a PIF file (zip).

Content Repository: An accessible digital storage system containing SCORM content packages.

Context-neutral Content: Context-neutral content can be separated from its SCORM package and still be considered complete. You can maintain context-neutrality by not referring to other SCOs, avoiding direct links to other SCOs or portions of the content, etc.

Control Mode: A value defined in the manifest file to define how Navigation Requests are applied to an aggregation.

Data Model Elements: A set of information about a learner's performance in, and interaction with, the instructional content initiated by the SCO and stored in an LMS. Data model elements are made interoperable by the SCORM Run Time Environment Data Model. The SCORM data model elements allow the LMS to collect data on the learners and their progress through the SCO. This data can then be used by the LMS for reporting purposes and to offer personalized content.

Durable: Durable content does not require modification to operate as versions of software systems and platforms are changed or upgraded.

Flow: A control mode that defines if the LMS may sequence move activities of this cluster using SCORM 2004 Sequencing.

Interactions: An element of the CMI data model used to track learner interaction with content. Typically used to track item level interactions in assessments.

Interoperable: Interoperable content operates across a wide variety of hardware, software, operating systems, and web browsers regardless of the tools used to create it and

the platform, such as a learning management system (LMS), on which it is initially delivered. SCORM-conformant content can easily be moved from one SCORM-compliant LMS to another.

Item: The XML element of the Manifest file representing the activities (SCO and/or aggregation) in the organization of a content package.

Learning Management System (LMS): An LMS is a software package used to administer one or more courses to one or more learners. An LMS is typically a web-based system that allows learners to authenticate themselves, register for courses, complete courses and take assessments. The LMS stores the learner's performance records and can provide assessment information to instructors.

Manifest: A manifest is a description of everything contained in your content package. Generally a tool such as the Reload Editor will be used to create the manifest as an XML document during the content packaging process. The manifest includes all of the resources or assets included in the content package, the content structure you created, the sequencing rules, and all the metadata for the SCOs and the package itself.

Metadata: Metadata is "data about data." It is the information that describes what your content is, both the individual pieces (the assets and SCOs) and the content packages. Metadata enables instructional designers searching for content or assets to locate them with relative ease and determine whether they will be useful before downloading or requesting rights to your content. The ADL Registry has a custom metadata taxonomy to which all metadata registered in it must adhere.

Navigation: The event of initiatiating the overall sequencing process. Typically initiated through requests such as "continue" or "previous" or by selecting an activity directly (choice).

Normalized Measure: The numeric value held in global objective. Typically used as a score and maps to the "score.scaled" element of the CMI data model when accessed from within the SCO.

Objective: In traditional instructional design, a learning objective is used to measure the attainment of a knowledge, skill, or ability in accordance with a predefined behavior, a prescribed condition, and an achievement standard. Your SCOs may each contain one objective or several objectives – it's up to you.

Your programmer may also use the term objectives, but it does not necessarily mean the same thing. When the programmer sets up sequencing, which are the rules that guide the way the content is presented to the learner, the variables that can store information about one SCO in the LMS that can be retrieved for later use to impact another SCO are also called "objectives." The programmer can use these objectives, at the ISD's direction, to do remediation automatically.

Objective Map: Used to define how a local objective is mapped to a global objective.

Organization: The organization is the part of a content package where SCOs are ordered into a structure and sequencing behaviors are assigned to them. The organization outlines

the entire structure you have created for your content. The organization provides order to the otherwise unordered collection of SCOs and their metadata.

Primary Objective: Used to define the objective that contributes to the rollup of an activity.

Progress Measure: The number used to track progress for an activity. This number is represented by a scaled decimal number between 0 and 1.

Remediation: Remediation is used to help learners comprehend instruction with which they may be struggling. In the event that learners do not answer a test item correctly, or fail an entire test, they can remediate to already-viewed content for review or completely new content to try and understand from a different approach. In SCORM 2004, remediation paths between SCOs can be created using sequencing rules.

Repository: A repository is a device for storing and maintaining digital information (content). Content proponents declare the existence of the data chunks in a registry for discovery and retrieval by others.

Resource: The XML element of the Manifest file that contains information for groups of assets used by SCOs in a content package.

Reuse: Reused content is existing content used in new or different contexts or applications. SCORM content can be reused in multiple ways: redeployed, repurposed, rearranged, or rewritten.

Rollup Rules: Rules used to define how tracking data is propagated up from a child activity to its parent.

Root Aggregation (See also organization): A root aggregation is a top-level aggregation.

Satisfied Status: This status is used to track whether or not an activity is passed or failed.

Shareable Content Object Reference Model (SCORM): SCORM is a model that references and integrates a set of interrelated technical standards, specifications, and guidelines designed to meet high-level requirements for e-learning content and systems.

Sequencing: Sequencing is similar to the ISD term "branching" in that it describes and prescribes the manner in which learners receive content. SCORM 2004 sequencing defines a method for representing the intended behavior of an authored learning experience such that any LMS will sequence discrete learning activities consistently, based upon rules created by the designer.

Sharable Content Object (SCO): In general terms, a SCO is a collection of assets that becomes an independent, defined piece of instructional material. SCOs are the smallest logical unit of instruction you can deliver and track via a learning management system (LMS).

SCORM 2004 API Wrapper

```
/*******************************************************************************
SCORM_2004_APIwrapper.js
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************************************************************************/
/************************************************************************
** Usage: Executable course content can call the API Wrapper
**      functions as follows:
**
**    javascript:
**          var result = doInitialize();
**          if (result != true)
**          {
**             // handle error
**          }
**
**    authorware:
**          result := ReadURL("javascript:doInitialize()", 100)
**
**    director:
**          result = externalEvent("javascript:doInitialize()")
**
**
************************************************************************/

var debug = true;  // set this to false to turn debugging off

var output = window.console; // output can be set to any object that has a
log(string) function
                             // such as: var output = { log:
function(str){alert(str);} };

// Define exception/error codes
var _NoError = {"code":"0","string":"No Error","diagnostic":"No Error"};;
var _GeneralException = {"code":"101","string":"General
Exception","diagnostic":"General Exception"};
var _AlreadyInitialized = {"code":"103","string":"Already
Initialized","diagnostic":"Already Initialized"};

var initialized = false;

// local variable definitions
var apiHandle = null;

/************************************************************************
**
```

```
** Function: doInitialize()
** Inputs:  None
** Return:  true if the initialization was successful, or
**          false if the initialization failed.
**
** Description:
** Initialize communication with LMS by calling the Initialize
** function which will be implemented by the LMS.
**
************************************************************************/
function doInitialize()
{
   if (initialized) return "true";

   var api = getAPIHandle();
   if (api == null)
   {
      message("Unable to locate the LMS's API Implementation.\nInitialize was
not successful.");
      return "false";
   }

   var result = api.Initialize("");

   if (result.toString() != "true")
   {
      var err = ErrorHandler();
      message("Initialize failed with error code: " + err.code);
   }
   else
   {
      initialized = true;
   }

   return result.toString();
}

/************************************************************************
**
** Function doTerminate()
** Inputs:  None
** Return:  true if successful
**          false if failed.
**
** Description:
** Close communication with LMS by calling the Terminate
** function which will be implemented by the LMS
**
************************************************************************
/
function doTerminate()
{
   if (! initialized) return "true";

   var api = getAPIHandle();
   if (api == null)
   {
      message("Unable to locate the LMS's API Implementation.\nTerminate was
not successful.");
      return "false";
   }
   else
   {
```

```
      // call the Terminate function that should be implemented by the API
      var result = api.Terminate("");
      if (result.toString() != "true")
      {
         var err = ErrorHandler();
         message("Terminate failed with error code: " + err.code);
      }
   }

   initialized = false;

   return result.toString();
}

/*******************************************************************************
**
** Function doGetValue(name)
** Inputs:  name - string representing the cmi data model defined category or
**             element (e.g. cmi.learner_id)
** Return:  The value presently assigned by the LMS to the cmi data model
**       element defined by the element or category identified by the name
**       input value.
**
** Description:
** Wraps the call to the GetValue method
**
*******************************************************************************
/
function doGetValue(name)
{
   var api = getAPIHandle();
   var result = "";
   if (api == null)
   {
      message("Unable to locate the LMS's API Implementation.\nGetValue was not
successful.");
   }
   else if (!initialized && ! doInitialize())
   {
      var err = ErrorHandler();
      message("GetValue failed - Could not initialize communication with the
LMS - error code: " + err.code);
   }
   else
   {
      result = api.GetValue(name);

      var error = ErrorHandler();
      if (error.code != _NoError.code)
      {
         // an error was encountered so display the error description
         message("GetValue("+name+") failed. \n"+ error.code + ": " +
error.string);
         result = "";
      }
   }
   return result.toString();
}

/*******************************************************************************
**
** Function doSetValue(name, value)
** Inputs:  name -string representing the data model defined category or
```

```
**          element value -the value that the named element or category will be
**          assigned
** Return:  true if successful
**          false if failed.
**
** Description:
** Wraps the call to the SetValue function
**
*******************************************************************************
/
function doSetValue(name, value)
{
   var api = getAPIHandle();
   var result = "false";
   if (api == null)
   {
      message("Unable to locate the LMS's API Implementation.\nSetValue was not
successful.");
   }
   else if (!initialized && !doInitialize())
   {
      var error = ErrorHandler();
      message("SetValue failed - Could not initialize communication with the
LMS - error code: " + error.code);
   }
   else
   {
      result = api.SetValue(name, value);
      if (result.toString() != "true")
      {
         var err = ErrorHandler();
         message("SetValue("+name+", "+value+") failed. \n"+ err.code + ": " +
err.string);
      }
   }

   return result.toString();
}

/*******************************************************************************
**
** Function doCommit()
** Inputs:  None
** Return:  true if successful
**          false if failed
**
** Description:
** Commits the data to the LMS.
**
*******************************************************************************
/
function doCommit()
{
   var api = getAPIHandle();
   var result = "false";
   if (api == null)
   {
      message("Unable to locate the LMS's API Implementation.\nCommit was not
successful.");
   }
   else if (!initialized && ! doInitialize())
   {
      var error = ErrorHandler();
```

```
      message("Commit failed - Could not initialize communication with the LMS
- error code: " + error.code);
   }
   else
   {
      result = api.Commit("");
      if (result != "true")
      {
         var err = ErrorHandler();
         message("Commit failed - error code: " + err.code);
      }
   }

   return result.toString();
}

/*******************************************************************************
**
** Function doGetLastError()
** Inputs:  None
** Return:  The error code that was set by the last LMS function call
**
** Description:
** Call the GetLastError function
**
*******************************************************************************
/
function doGetLastError()
{
   var api = getAPIHandle();
   if (api == null)
   {
      message("Unable to locate the LMS's API Implementation.\nGetLastError was
not successful.");
      //since we can't get the error code from the LMS, return a general error
      return _GeneralException.code;
   }

   return api.GetLastError().toString();
}

/*******************************************************************************
**
** Function doGetErrorString(errorCode)
** Inputs:  errorCode - Error Code
** Return:  The textual description that corresponds to the input error code
**
** Description:
** Call the GetErrorString function
**
*******************************************************************************
*/
function doGetErrorString(errorCode)
{
   var api = getAPIHandle();
   if (api == null)
   {
      message("Unable to locate the LMS's API Implementation.\nGetErrorString
was not successful.");
      return _GeneralException.string;
   }

   return api.GetErrorString(errorCode).toString();
```

```
}

/*******************************************************************************
**
** Function doGetDiagnostic(errorCode)
** Inputs:  errorCode - Error Code(integer format), or null
** Return:  The vendor specific textual description that corresponds to the
**          input error code
**
** Description:
** Call the LMSGetDiagnostic function
**
*******************************************************************************
/
function doGetDiagnostic(errorCode)
{
   var api = getAPIHandle();
   if (api == null)
   {
      message("Unable to locate the LMS's API Implementation.\nGetDiagnostic
was not successful.");
      return "Unable to locate the LMS's API Implementation. GetDiagnostic was
not successful.";
   }

   return api.GetDiagnostic(errorCode).toString();
}

/*******************************************************************************
**
** Function ErrorHandler()
** Inputs:  None
** Return:  The current error
**
** Description:
** Determines if an error was encountered by the previous API call
** and if so, returns the error.
**
** Usage:
** var last_error = ErrorHandler();
** if (last_error.code != _NoError.code)
** {
**    message("Encountered an error. Code: " + last_error.code +
**                                 "\nMessage: " + last_error.string +
**                                 "\nDiagnostics: " + last_error.diagnostic);
** }
*******************************************************************************
/
function ErrorHandler()
{
   var error = {"code":_NoError.code, "string":_NoError.string,
"diagnostic":_NoError.diagnostic};
   var api = getAPIHandle();
   if (api == null)
   {
      message("Unable to locate the LMS's API Implementation.\nCannot determine
LMS error code.");
      error.code = _GeneralException.code;
      error.string = _GeneralException.string;
      error.diagnostic = "Unable to locate the LMS's API Implementation. Cannot
determine LMS error code.";
      return error;
   }
```

```
   // check for errors caused by or from the LMS
   error.code = api.GetLastError().toString();
   if (error.code != _NoError.code)
   {
      // an error was encountered so display the error description
      error.string = api.GetErrorString(error.code);
      error.diagnostic = api.GetDiagnostic("");
   }

   return error;
}

/*****************************************************************************
**
** Function getAPIHandle()
** Inputs:  None
** Return:  value contained by APIHandle
**
** Description:
** Returns the handle to API object if it was previously set,
** otherwise it returns null
**
*****************************************************************************
/
function getAPIHandle()
{
   if (apiHandle == null)
   {
      apiHandle = getAPI();
   }

   return apiHandle;
}


/*****************************************************************************
**
** Function findAPI(win)
** Inputs:  win - a Window Object
** Return:  If an API object is found, it's returned, otherwise null is
** returned
**
** Description:
** This function looks for an object named API_1484_11 in parent and opener
** windows
**
*****************************************************************************
/
function findAPI(win)
{
   var findAPITries = 0;
   while ((win.API_1484_11 == null) && (win.parent != null) && (win.parent !=
win))
   {
      findAPITries++;

      if (findAPITries > 500)
      {
         message("Error finding API -- too deeply nested.");
         return null;
      }
```

```
      win = win.parent;

   }
   return win.API_1484_11;
}

/*******************************************************************************
**
** Function getAPI()
** Inputs:  none
** Return:  If an API object is found, it's returned, otherwise null is
**          returned
**
** Description:
** This function looks for an object named API_1484_11, first in the current
** window's frame hierarchy and then, if necessary, in the current window's
** opener window hierarchy (if there is an opener window).
**
*******************************************************************************
/
function getAPI()
{
   var theAPI = findAPI(window);
   if ((theAPI == null) && (window.opener != null) && (typeof(window.opener) !=
"undefined"))
   {
      theAPI = findAPI(window.opener);
   }
   if (theAPI == null)
   {
      message("Unable to find an API adapter");
   }
   return theAPI
}

/*******************************************************************************
**
** Function findObjective(objId)
** Inputs:  objId - the id of the objective
** Return:  the index where this objective is located
**
** Description:
** This function looks for the objective within the objective array and returns
** the index where it was found or it will create the objective for you and
** return the new index.
**
*******************************************************************************
/
function findObjective(objId)
{
    var num = doGetValue("cmi.objectives._count");
    var objIndex = -1;

    for (var i=0; i < num; ++i) {
        if (doGetValue("cmi.objectives." + i + ".id") == objId) {
            objIndex = i;
            break;
        }
    }

    if (objIndex == -1) {
        message("Objective " + objId + " not found.");
        objIndex = num;
```

```
        message("Creating new objective at index " + objIndex);
        doSetValue("cmi.objectives." + objIndex + ".id", objId);
    }
    return objIndex;
}

/*******************************************************************************
** NOTE: This is a SCORM 2004 4th Edition feature.
**
** Function findDataStore(id)
** Inputs:  id - the id of the data store
** Return:  the index where this data store is located or -1 if the id wasn't
**          found
**
** Description:
** This function looks for the data store within the data array and returns
** the index where it was found or returns -1 to indicate the id wasn't found
** in the collection.
**
** Usage:
** var dsIndex = findDataStore("myds");
** if (dsIndex > -1)
** {
**    doSetValue("adl.data." + dsIndex + ".store", "save this info...");
** }
** else
** {
**    var appending_data = doGetValue("cmi.suspend_data");
**    doSetValue("cmi.suspend_data", appending_data + "myds:save this info");
** }
*******************************************************************************
/
function findDataStore(id)
{
    var num = doGetValue("adl.data._count");
    var index = -1;

    // if the get value was not null and is a number
    // in other words, we got an index in the adl.data array
    if (num != null && ! isNaN(num))
    {
       for (var i=0; i < num; ++i)
       {
           if (doGetValue("adl.data." + i + ".id") == id)
           {
               index = i;
               break;
           }
       }

       if (index == -1)
       {
           message("Data store " + id + " not found.");
       }
    }

    return index;
}

/*******************************************************************************
**
** Function message(str)
** Inputs:  String - message you want to send to the designated output
```

```
** Return:  none
** Depends on: boolean debug to indicate if output is wanted
**             object output to handle the messages. must implement a function
**             log(string)
**
** Description:
** This function outputs messages to a specified output. You can define your
** own output object. It will just need to implement a log(string) function.
** This interface was used so that the output could be assigned the
** window.console object.
*******************************************************************************
/
function message(str)
{
   if(debug)
   {
      output.log(str);
   }
}
```

Index