



IEEE Standard for Learning Technology—Data Model for Content Object Communication

IEEE Computer Society

Developed by the
Learning Technology Committee

IEEE Std 1484.11.1™-2022
(Revision of IEEE Std 1484.11.1-2004)



STANDARDS

IEEE Standard for Learning Technology—Data Model for Content Object Communication

Developed by the

Learning Technology Committee
of the
IEEE Computer Society

Approved 9 February 2022

IEEE SA Standards Board

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Abstract: A data model to support the interchange of data elements and their values between a content object and a runtime service (RTS) is described in this standard. This standard is based on a current industry practice called “computer managed instruction” (CMI). The work on which this standard is based was developed to support a client–server environment in which a learning technology system, generically called a “learning management system” (LMS), delivers digital content, called “content objects,” to learners. The data model supports learner data and preferences; interactions; objectives; content-object entry, exit, and status information; time parameters; and scores.

Keywords: content object, computer managed instruction (CMI), data model, IEEE 1484.11.1™, interoperability, learning content, learning management system (LMS), runtime service (RTS)

The Institute of Electrical and Electronics Engineers, Inc.
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PDF: ISBN 978-1-5044-8468-8 STD25259
Print: ISBN 978-1-5044-8469-5 STDPD25259

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Introduction

This introduction is not part of IEEE Std 1484.11.1-2022, IEEE Standard for Learning Technology—Data Model for Content Object Communication.

This standard describes a data model to support the interchange of agreed-upon data elements and their values between a learning-related content object and a runtime service (RTS) used to support learning management.

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IEEE Standard for Learning Technology— Data Model for Content

Object ~~to Learning Management System~~ Communication

1. Overview

~~The scope and purpose of this Standard are discussed in 1.1 and 1.2.~~

1.1 Scope

This standard describes a data model to support the interchange of agreed-upon data elements and their values between a learning-related content object and a runtime service (RTS) used to support learning management. This standard does not specify the means of communication between a content object and an RTS nor how any component of a learning environment shall behave in response to receiving data in the form specified. This standard is based on a related data model defined in “Computer Managed Instruction (CMI) Guidelines For Interoperability,” version 3.5 [B1]⁶ by the Aviation Industry CBT Committee (AICC).¹ To balance the need to support existing implementations with the need to make technical corrections and support emerging practice, this standard selectively includes those data elements from the CMI specification that are commonly implemented;⁷ renames some data elements taken from the CMI specification to clarify their intended meaning;⁸ modifies the data types of data elements taken from the CMI specification to reflect ISO standard data types and internationalization requirements;⁹ removes some organizational structures used in the CMI specification to group data elements that are specific to the AICC community of practice and not generally applicable;¹⁰ and introduces some data elements not present in the CMI specification to correct known technical deficiencies in data elements taken from that specification.

^{6,1} The numbers in brackets correspond to those of the bibliography in Annex A.

1.2 Purpose

There is widespread acknowledgment that the data model for content object communication defined in the AICC “Computer Managed Instruction (CMI) Guidelines for Interoperability”, version 3.5 [B1], has broad applicability to systems used for learning management. The purpose of this standard is to build consensus around, resolve ambiguities in, and correct defects in the AICC data model for the data exchanged between learning-related content objects and an RTS used to support learning management.

1.3 Word usage

The word *shall* indicates mandatory requirements strictly to be followed in order to conform to the standard and from which no deviation is permitted (*shall* equals *is required to*).^{7, 8}

The word *should* indicates that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required (*should* equals *is recommended that*).

The word *may* is used to indicate a course of action permissible within the limits of the standard (*may* equals *is permitted to*).

The word *can* is used for statements of possibility and capability, whether material, physical, or causal (*can* equals *is able to*).

⁷ The use of the word *must* is deprecated and cannot be used when stating mandatory requirements, *must* is used only to describe unavoidable situations.

⁸ The use of *will* is deprecated and cannot be used when stating mandatory requirements, *will* is only used in statements of fact.

2. Normative references

The following referenced documents are indispensable for the application of this [document \(i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained\)](#). ~~Standard~~. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments [or corrigenda](#)) applies.

IETF RFC 2396, Uniform Resource Identifiers (URI): Generic Syntax.^{[9](#) [2](#)}

ISO 639-1, Code for the representation of names of languages—Part 1: Alpha-2 code.^{[10](#) [3](#)}

ISO 639-2, Codes for the representation of names of languages—Part 2: Alpha-3 code.

ISO 3166-1, Codes for the representation of names of countries and their subdivisions—Part 1: Country codes.

ISO 8601:2000, Data elements and interchange formats – Information interchange—Representation of dates and times.

^{[9](#) [2](#)} [Internet Requests for Comments \(RFCs\)](#) ~~IETF publications~~ are available on the World Wide Web ~~at from~~ the following [ftp site](#): [venera.isi.edu; logon: anonymous; password: user's e-mail address; directory: in-inotes](#) ~~website: http://www.ietf.org.~~

^{[10](#) [3](#)} ISO publications are available from the [International Organization for Standardization](#) ~~ISO Central Secretariat, Case Postale 56, 1 rue de Varembe, CH 1211, Genève 20, Switzerland/Suisse~~ (<https://www.iso.org/> ~~http://www.iso.ch/~~); ~~and the ISO publications are also available in the United States from the Sales Department, American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036, USA~~ ([https](https://www.ansi.org/) ~~http://www.ansi.org/~~).

ISO/IEC 10646-1, Information technology—Universal Multiple-Octet Coded Character Set (UCS)—
Part 1: Architecture and Basic Multilingual Plane.¹¹

~~ISO/IEC 646:1991, Information technology—ISO 7 bit coded character set for information interchange.⁴~~

~~ISO/IEC 11404:1996, Information technology—Programming languages, their environments and system software interfaces—Language independent datatypes.~~

3. Definitions, acronyms, and abbreviations

3.1 Definitions

For the purposes of this document ~~Standard~~, the following terms and definitions apply. The ~~Authoritative Dictionary of IEEE Standards Terms [B2]~~ Dictionary Online should be consulted ~~referenced~~ for terms not defined in this clause.¹²

content object: A collection of digital content that is intended for presentation to a learner by a learning technology system. A content object ~~It~~ may include learning material and processing code.

NOTE— ~~Example:~~ A content object might be an HTML page with an embedded video clip and an ECMAScript component written in accordance with IEEE ~~Std~~ 1484.11. 2TM–2003. ~~For more information on IEEE Std 1484.11.2–2003, see [B2 B3].~~^{13 5}

^{11 4}~~ISO/IEC publications are available from the International Electrotechnical Commission (<https://www.iec.ch>) and the American National Standards Institute (<https://www.ansi.org/>). ISO Central Secretariat, Case Postale 56, 1 rue de Varembe, CH 1211, Genève 20, Switzerland/Suisse (<http://www.iso.ch/>). ISO/IEC publications are also available in the United States from Global Engineering Documents, 15 Inverness Way East, Englewood, Colorado 80112, USA (<http://global.ihs.com/>). Electronic copies are available in the United States from the American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036, USA (<http://www.ansi.org/>).~~

¹²~~IEEE Standards Dictionary Online is available at: <http://dictionary.ieee.org>. An IEEE Account is required for access to the dictionary, and one can be created at no charge on the dictionary sign-in page.~~

^{13 5} Notes in text, tables, and figures of a standard are given for information only and do not contain requirements needed to implement this ~~the~~ standard.

implementation defined (adj.): An indication that the implementation provider shall define and document the requirements for correct program constructs and correct data of a value or behavior. When the value or behavior in the implementation is designed to be variable or customizable on each instantiation of the system, the implementation provider shall document the nature and permissible ranges of this variation.

interaction: A recognized and recordable input or group of inputs from a learner to a content object.

launch (v.): To cause a content object to be delivered to a learner.

learner attempt: A tracked effort by a learner to satisfy the requirements of a learning activity that uses a content object. [A learner attempt](#) ~~It~~ may span one or more learner sessions and [may](#) be suspended between learner sessions. *See also:* **learner session**.

learner: An individual engaged with a learning technology system [in order](#) to acquire knowledge or skills.

NOTE—The learner attempt begins with the beginning of the first learner session and continues until the learning activity terminates.

learner session: An uninterrupted period of time during which a learner is accessing a content object. *See also:* **learner attempt**.

learning management system (LMS): A computer system that may include the capabilities to register learners, schedule learning resources, control and guide the learning process, analyze and report learner performance, and schedule and track learners. *See also:* **runtime service**.

NOTE—Some implementations of learning management systems also have the ability to launch and deliver content. For this standard, these capabilities are known as a runtime service.

runtime service (RTS): Software that controls the execution and delivery of learning content and that may provide services such as resource allocation, scheduling, input-output control, and data management. *See also:* **learning management system**.

score: A numerical value or a point on a descriptive scale. A score may be the result of a learner assessment.

3.2 Acronyms and abbreviations

AICC	Aviation Industry CBT Committee
CMI	computer managed instruction
IANA	Internet Assigned Numbers Authority
LMS	learning management system
RTS	runtime service
SPM	smallest permitted maximum
URI	Uniform Resource Identifier
URN	Uniform Resource Name

4. Conformance

Conformance to this standard is discussed in 4.1 [through](#) – 4.6.

In this standard, “shall” is to be interpreted as a requirement on an implementation; “shall not” is to be interpreted as a prohibition.

4.1 Data instances

A conforming data instance shall be an instance of the data model as defined in [5.6](#) 1.

4.2 Sending implementations

A conforming sending implementation shall send data instances that conform to this standard.

4.3 Receiving implementations

A conforming receiving implementation shall accept data instances that conform to this standard.

4.4 Repository implementations

A conforming repository implementation shall accept, store, and provide data that [conforms](#) ~~conform~~ to this standard upon request.

4.5 Implementation-defined values

The processing and meanings of values that are not specified by this standard (e.g., sentinel, missing, and empty values) are implementation-~~defined~~.

NOTE—For example, bindings, application profiles, or implementations may specify the processing or meanings of default values or sentinel values for specific data elements. An application profile might specify that in the absence of another value, the default value for mode is normal.

4.6 Smallest permitted maximum values

This standard defines [smallest permitted maximum](#) (SPM) values for data elements with data types that include bag, array, set, and characterstring. For these data elements, a receiving implementation or a repository implementation that conforms to this standard shall accept and process at least that number of entries or characters specified by the SPM for the element and may accept and process a larger number.

~~NOTES~~

[NOTE](#) 1—The intent is for the SPM values to cover most cases.

[NOTE](#) 2—In this subclause, the meaning of “processing” is dependent on the nature of the application.

[NOTE](#) 3—This standard defines no provisions for how and whether a sending system can determine whether a receiving system can process more than the SPM for a particular data element.

5. Data model

This clause defines a data model that a content object can use for obtaining information from an RTS to enable the content object to perform its expected functions and that an RTS can use for obtaining information from a content object to enable the RTS to manage the content object properly. The data model provides a description of the information that may pass to and from the content object.

This standard does not specify how, when, or in which direction the information may flow. In addition, this standard does not specify persistence of the data, how often it may be written or rewritten, or by whom it may be created or destroyed.

Unless noted otherwise, all components of “records” are optional in a data instance.

NOTES

[NOTE 1](#)—The use of ISO/IEC 11404 notation in the synopses in [5. 6 1](#) and [5. 6 2](#) is for descriptive purposes only.⁶ A complete implementation of the operations defined in ISO/IEC 11404 is not required for conformance.

[NOTE 2](#)—The ISO/IEC 11404 notation describes the semantics of the language-independent data types across all bindings (e.g., implementation of a data type as itself, its subtypes, its subclasses, and its specializations). For example, an ISO/IEC 11404 “array” may be implemented as an SQL table (because SQL tables support indexing, a requirement for arrays); an ISO/IEC 11404 “state” may be implemented as a C programming language bit field; an ISO/IEC 11404 “characterstring” may be implemented in any encoding (e.g., ISO 646, ASCII, ISO 8859–1, UTF–8, UTF–16, [and](#) UTF–32, ~~etc.~~) that supports the repertoire specified in the parameter for the characterstring data type.

[NOTE 3](#)—All examples in [5. 6 1](#) and [5. 6 2](#) are informative and do not endorse any particular binding.

[NOTE 4](#)—The following language-independent data types are defined in ISO/IEC 11404: [\(see Annex B\)](#): array, bag, characterstring, choice, real, record, set, state, time, and timeinterval.

[NOTE 5](#)—The data element and data type labels used in the synopses in [5.6.1](#) and [5.6.2](#) are for reference only. Implementations are not required to use the ~~exact~~ same labels, as long as the data elements and data types are semantically equivalent. It is recommended that implementations use spellings for labels similar to the spellings specified in this standard.

[NOTE 6](#)—This standard does not define an extension mechanism for the data model. Implementers may create additional data models for content object communications. Such additional data models may be used to augment this data model to support different communities of practice.

5.1 Content object communication

Synopsis

```
content_object_communication :
record
(
  comments_from_learner :
    array(0..249) of comment_type,
    // the SPM for the array is 250
  comments_from_lms :
    array(0..99) of comment_type,
    // the SPM for the array is 100
  completion_status :
    completion_status_type,
  completion_threshold :
    real(10,7) range(0..1),
  credit :
    state( credit, no_credit ),
  data_model_version :
    characterstring(iso-10646-1),
    // SPM: 250 characters
  entry :
    state( ab_initio, resume, _nil_ ),
  exit :
    state( timeout, suspend, logout, normal, _nil_ ),
  interactions :
    bag of interaction_type,
    // SPM: 250 interaction_type records in the bag
  launch_data :
    characterstring(iso-10646-1),
    // SPM: 4000 characters
  learner_id :
    long_identifier_type,
  learner_name :
    localized_string_type(250),
```

```

        // the parameter value is the SPM
learner_preference_data :
    learner_preference_type,
lesson_status :
    state( passed, completed, failed, incomplete, browsed,
        not_attempted ),
location :
    characterstring(iso-10646-1),
    // SPM: 1000 characters
max_time_allowed :
    timeinterval(second,10,2),
mode :
    state( browse, normal, review ),
objectives :
    set of objective_type,
    // SPM: 100 objective_type records in the bag
progress_measure :
    progress_measure_type,
raw_passing_score :
    real(10,7),
scaled_passing_score :
    real(10,7) range(-1..1),
score :
    score_type,
session_time :
    timeinterval(second,10,2),
success_status :
    success_status_type,
suspend_data :
    characterstring(iso-10646-1),
    // SPM: 4000 characters
time_limit_action :
    state( exit_message, continue_message, exit_no_message,
        continue_no_message ),
total_time :
    timeinterval(second,10,2),
),

```

Description

The components of content_object_communication are defined in [5. 6 1.1 through 5. 6 1.27](#). Depending on the direction, destination, and purpose of the communication, an instance of content_object_communication shall include zero or more of the defined components.

5.1.1 Comments from learner

Synopsis

```
comments_from_learner :  
  
    array(0..249) of comment_type,  
  
    // the SPM for the array is 250
```

Description

The values of this data element are comments from the learner.

Subclause 5.2.1 defines comment_type.

NOTES

[NOTE 1](#)—The values of this data element are intended to provide feedback about the content object or the learning experience with the content object from a specific learner. Using this data element for other purposes may adversely affect interoperability.

[NOTE 2](#)—This standard does not specify the mechanism for collecting comments.

5.1.2 Comments from LMS

Synopsis

```
comments_from_lms :  
  
    array(0..99) of comment_type,  
  
    // the SPM for the array is 100
```

Description

The values of this data element are comments and annotations intended to be made available to the learner.

Subclause 5.2.1 defines `comment_type`.

NOTES

[NOTE 1](#)—The values of this data element are intended to provide information about the content object or the learning experience with the content object. Using this data element for other purposes may adversely affect interoperability. [NOTE 2](#)—This standard does not specify the mechanism for collecting comments.

5.1.3 Completion status

Synopsis

`completion_status :`

`completion_status_type,`

Description

The value of this data element indicates whether the learner has completed the content object.

Subclause 5.2.2 defines `completion_status_type`.

NOTE—This standard does not specify how to determine `completion_status`. It may be reported by a content object, determined by an `RTSL` by comparing a progress measure with a threshold, determined on the basis of objectives set by an outside agent (e.g., an instructor), or determined by some other means.

5.1.4 Completion threshold

Synopsis

completion_threshold :

real(10,7) range(0..1),

Description

The value of this data element is a value against which the measure of the progress the learner has made toward completing the content object can be compared to determine whether the content object should be considered completed.

NOTE—The `completion_threshold` is designed to be used in conjunction with the `progress_measure` (see 5.1.19). For example, if the `completion_threshold` for a content object is 0.85 and a learner achieves a `progress_measure` of 0.90, a `completion_status` of completed (see 5.1.3) may be assigned to that content object for that learner. However, this standard does not specify or require that an RTS, content object, or any other system component ⁷ interpret or take action in response to a `completion_threshold`.

5.1.5 Credit

Synopsis

credit :

state(credit, no_credit),

Description

The value of this data element indicates whether the learner will be credited for performance in this content object. This data element shall have one of the following permissible values:

- credit: The learner is taking the content object for credit.
- no_credit: The learner is taking the content object for no credit.

NOTE—This standard does not specify how to determine the value of credit or what it means to give credit for performance.

5.1.6 Data model version

Synopsis

```
data_model_version :  
  
    characterstring(iso-10646-1),  
  
    // SPM: 250 characters
```

Description

The value of this data element indicates the version of the data model defined in this standard. The value shall consist of a period-delimited string containing major and minor release values as whole numbers; for example, “1.0”. Any characters appearing after the minor release value shall be separated from the minor release value by a period (“.”). The syntax and semantics of any characters following the minor release value are not specified by this standard.

For this edition of this standard, the major version number shall be “1” and the minor version number shall be “0”. Therefore, the first three characters of the value shall be “1.0”.

An implementation may append additional characters to the value of this data element; in which case, the first four characters shall be “1.0”.