SERIES Y: GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS, NEXT-GENERATION NETWORKS, INTERNET OF THINGS AND SMART CITIES

Next Generation Networks – Service aspects: Service capabilities and service architecture

Service framework to support web objects based ubiquitous self-directed learning

Recommendation ITU-T Y.2241

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Recommendation ITU-T Y.2241

Service framework to support web objects based ubiquitous self-directed learning

Summary

Recommendation ITU-T Y.2241 provides a framework to support a web objects based ubiquitous self-directed learning (uSDL) service including overview, content object model, functional capabilities, security and trust considerations of web objects based uSDL.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T Y.2241	2017-09-13	13	11.1002/1000/13348

Keywords

Composite virtual object, contents objects database, ubiquitous self-directed learning, virtual object, web of objects.

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* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

FOREWORD

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As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at http://www.itu.int/ITU-T/ipr/.

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Service framework to support web objects based ubiquitous self-directed learning

1 Scope

A web objects based ubiquitous self-directed learning (uSDL) service provides the educational capabilities in a setting of pervasive or omnipresent computing environment to support various contexts of learner's situations and capabilities.

This Recommendation provides the followings:

– an overview of web objects based uSDL;

– a content object model of web objects based uSDL;

– functional capabilities for web objects based uSDL;

– security support for web objects based uSDL environment;

– trust provisioning of web objects based uSDL.

Two appendices have been provided. Appendix I indicates an example of an architecture to support smart uSDL entity perspectives and provides an associated model. Appendix II provides an example of an architecture to support smart uSDL entity perspectives.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T X.1314]   Recommendation ITU-T X.1314 (2014), *Security requirements and framework of ubiquitous networking*.

[ITU-T Y.4000]   Recommendation ITU-T Y.4000/Y.2060 (2012), *Overview of the Internet of things*.

[ITU-T Y.4452]   Recommendation ITU-T Y.4452 (2016), *Functional framework of web of objects*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 composite virtual object (CVO) [ITU-T Y.4452]: A collection of multiple VOs to abstract a service feature, operation or management function, to enable the mash-up and collaboration.

3.1.2 information model [ITU-T Y.4452]: A model to define how the elements (i.e., VO and CVO) in an information environment are represented as a common set of objects and relationships between them.

3.1.3 **Internet of things (IoT)** [ITU-T Y.4000]: A global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies.

NOTE 1 – Through the exploitation of identification, data capture, processing and communication capabilities, the IoT makes full use of things to offer services to all kinds of applications, whilst ensuring that security and privacy requirements are fulfilled.

NOTE 2 – From a broader perspective, the IoT can be perceived as a vision with technological and societal implications.

3.1.4 **object** [b-ITU-T Y.2002]: An intrinsic representation of an entity that is described at an appropriate level of abstraction in terms of its attributes and functions.

NOTE 1 – An object is characterized by its behaviour. An object is distinct from any other object. An object interacts with its environment including other objects at its interaction points. An object is informally said to perform functions and offer services (an object which makes a function available is said to offer a service). For modelling purposes, these functions and services are specified in terms of the behaviour of the object and of its interfaces. An object can perform more than one function. A function can be performed by the cooperation of several objects.

NOTE 2 – Objects include terminal devices (e.g., used by a person to access the network such as mobile phones, personal computers), remote monitoring devices (e.g., cameras, sensors), information devices (e.g., content delivery server), products, contents, and resources.

3.1.5 **resource** [b-IETF RFC 3986]: This specification does not limit the scope of what might be a resource; rather, the term "resource" is used in a general sense for whatever might be identified by a uniform resource identifier (URI).

3.1.6 **virtual object (VO)** [ITU-T Y.4452]: A virtual representation of a real world object (e.g., sensor, device, task, process and information).

NOTE – Real world objects are identifiable through their virtual representation.

3.1.7 **Web of Objects (WoO)** [ITU-T Y.4452]: A way to incorporate virtual objects on the World Wide Web and to facilitate the creation of IoT services.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 **self-directed learning (SDL)**: A process by which individuals take the initiative, with or without the assistance of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes.

3.2.2 **ubiquitous-learning (u-learning)**: Learning in a ubiquitous computing environment at anywhere and anytime closely associated with mobile technologies.

3.2.3 **ubiquitous self-directed learning (uSDL)**: A self-directed learning (SDL) process in a ubiquitous computing environment.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AI   Artificial Intelligence

COD   Contents Objects Database

COI   Community of Interest

CVO   Composite Virtual Object

CVOs   Composite Virtual Objects

IoT	Internet of Things
LMS	Learning Management Systems
LOM	Learning Objects Metadata
RDF	Resource Description Framework
SDL	Self-Directed Learning
SLA	Service Level Agreement
u-learning	ubiquitous-learning
URI	Uniform Resource Identifier
URL	Uniform Resource Locator
uSDL	ubiquitous Self-Directed Learning
UI/UX	User Interface/User Experience
VO	Virtual Object
WoO	Web of Objects
XML	Extensible Markup Language

5   Conventions

None.

6   Overview of web objects based uSDL

6.1   General features of uSDL

The functional features of uSDL provides the means for mobile learning, including a mobile and pervasive or omnipresent educational environment. uSDL supports adaptive learning methodologies in accordance with the learner's preference, learning situations and the learner's level of understanding.

uSDL enables learners to access educational objects flexibly and seamlessly in both a pervasive and a persistent environment. A learner may move or locate around ubiquitous space and collaborate with various learning objects (texts, media and all educational materials) to get learning information.

The uSDL content objects are created via a virtualization process from physical digital text, images and other media such as presentations, streamed audio, or video files. The information model of uSDL content objects is in accordance with [ITU-T Y.4452].

Thus, uSDL promotes the following enhanced educational effects:

−   a learner is empowered to take increasingly more responsibility for various decisions associated with the learning endeavour;

−   a learner is able to transfer learning in terms of both knowledge and study skill;

−   uSDL supports various activities and resources, such as self-guided reading, participation in study groups, internships, electronic dialogues, and reflective writing activities;

−   uSDL gives the learner the opportunity to access educational materials at different times from different locations.

6.2 Service provisioning model of web objects based uSDL

As shown in [ITU-T Y.4452], the WoO facilitates distributed applications to combine educational information from different domains. The web objects based uSDL provides an easy creation of cross-domain learning environments, simplifying the learning application deployment, maintenance and operation through virtualization procedure of educational digital contents.

Web objects based uSDL is composed of the following three components:

– uSDL learners: they will be placed adjacent or remote to the objects and terminal devices. The presence of uSDL learners will be recognized by sensors to include proximity, to sense movement and to detect changes in light intensity, etc. Their situation information will be shared with the objects in uSDL environments.

– web objects based uSDL environment: a u-learning service environment to support web objects based uSDL service in accordance with [ITU-T Y.4452].

– educational content objects database (COD), database and information provision environment: a database environment to provide educational contents objects and information for uSDL service provision.

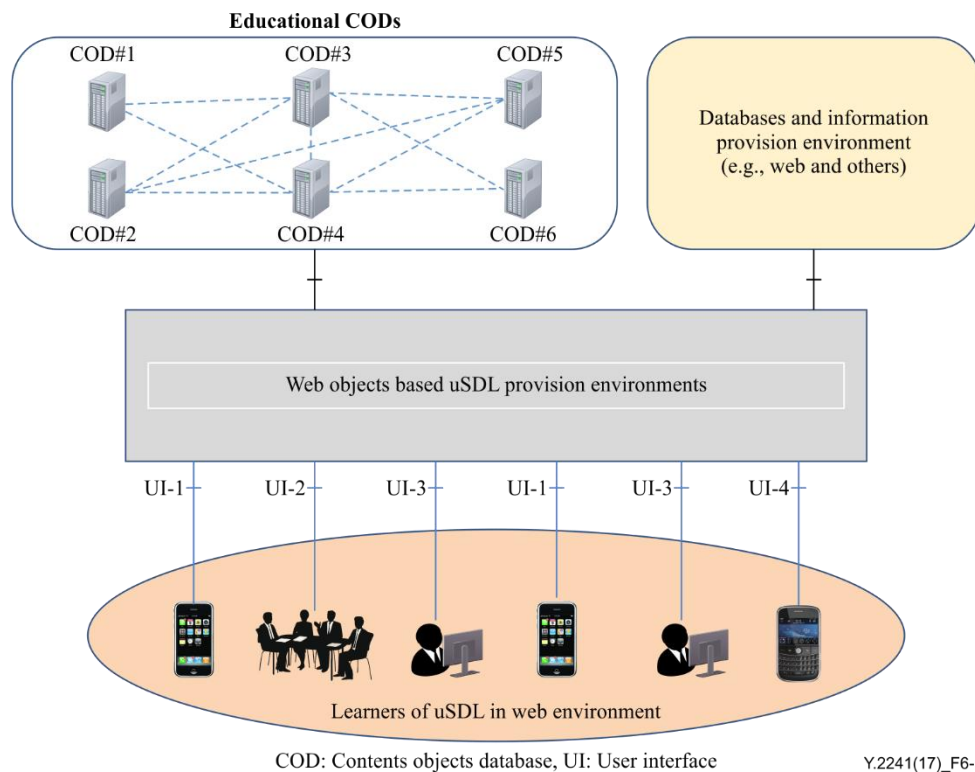Figure 6-1 shows a service provisioning model of web objects based uSDL.

Figure 6-1 – A service provisioning model of web objects based uSDL

7 Educational content object model in web objects based uSDL

7.1 Structure of educational content objects

The educational content objects in uSDL are characterized by the relationship among educational objects to provide learning contents and system resources as indicated in [ITU-T Y.4452]. The various existing educational content objects in the web environment collaborate using multiple sets of required metadata. The objects that are used to provide for the uSDL will be text, video, media, and a different field of omnipresence provided to users according to their specific selection of prepared learning materials.

Figure 7-1 illustrates an educational content objects model in the web objects based uSDL provision environments. This is consistent with the functional framework of web of objects captured in [ITU-T Y.4452].
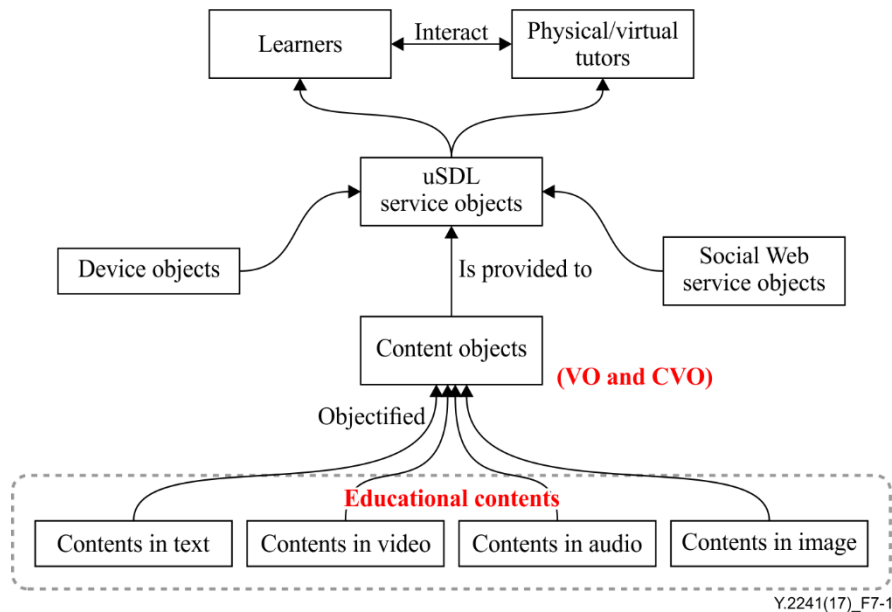

Figure 7-1 – Educational content objects model in web objects based uSDL environment

7.2 Content objects attributes in web objects based uSDL

In the web objects based uSDL, multiple types of content objects as shown in Figure 7-1 are created with the inclusion of attribute information. The typical attribute information are as follows:

– general attributes;

– life cycle attribute;

– technical attribute;

– educational attribute;

– rights;

– relation;

– annotation.

7.2.1 General attributes

The general attributes of the uSDL content objects are based on [ITU-T Y.4452], and these are as follows:

– identifier: a globally unique label that identifies the uSDL object;

– title: name given to the uSDLobject;

– language: the primary human language or languages used within the uSDL object to communicate to the intended user;

– description: a textual description of the content of a uSDLobject;

– keyword: a keyword or phrase describing the topic of a uSDL object;

– coverage: the time, culture, geography or the region to which the uSDL object applies;

– structure: underlying organizational structure of the education object;

– aggregation level: the functional granularity of the uSDL object.

7.2.2 Life cycle attribute

The life cycle attribute describes the history and current state of the objects in uSDL, and the life cycle attributes are as follows:

– version: the edition of the uSDL object;

– status: the completion status or condition of the uSDL object;

– contribute: those entities (i.e., people, organizations) that have contributed to the state of the uSDL object during its life cycle (e.g., creation, edits, publication):

- role: kind of contribution;

- entity: the identification of and information about entities (i.e., people, organizations) contributing to the uSDL object;

- date: the date of the contribution.

7.2.3 Technical attribute

The technical attribute describes the technical requirements and characteristics of the service objects in uSDL, and the technical attributes are as follows:

– format: technical data type(s) of the uSDL object;

– size: the size of the digital object in bytes. The size is represented as a decimal value;

– location: a string that is used to access the uSDL object. It may be a location (e.g., uniform resource locator (URL)), or a method that resolves to a location (e.g., URI);

– requirement: the technical capabilities necessary for using the uSDL object;

– duration: the time a continuous learning object takes when played at intended speed.

7.2.4 Educational attribute

The educational attribute specifies the key educational or pedagogical characteristics of the uSDL object:

– interactivity type: predominant mode of learning supported by the uSDL object;

– learning resource type: specific kind of learning object;

– interactivity level: the degree of interactivity characterizing the uSDL object. Interactivity in this context refers to the degree to which the learner can influence the aspect or behaviour of the uSDL object;

– semantic density: the degree of conciseness of a uSDL object. The semantic density of an object may be estimated in terms of its size, span, or duration;

– intended end user role: principal user(s) for which the uSDL object was first designed;

– context: the principal environment within which the learning and use of the uSDL object is intended to take place;

– typical age range: age of the typical intended user;

– difficulty: how hard it is to work with or through the uSDL object for the typical intended target audience;

– typical learning time: approximate or typical time it takes to work with or through this learning object for the typical intended target audience;

– description: comments on how the object is to be used.

7.2.5 Right

The rights attribute describes the intellectual property rights and conditions of use for the uSDL objects:

–	cost: whether the use of the uSDL object requires payment;

–	copyright: whether copyright applies to the use of the uSDL object;

–	description: comments on the conditions of use of the uSDL object.

7.2.6 Relation

The relation attribute defines the relationship between uSDL objects The attributes are as follows:

–	kind: nature of the relationship between this uSDL object and the target uSDL object;

–	resource: the target uSDL object that this relationship references. A resource attribute also includes the identifier and description attributes.

7.2.7 Annotation

The annotation attribute provides the following comments on the educational use of the uSDL content, and information on when and by whom the comments are created:

–	entity: entity (i.e., people, organization) that created the annotation;

–	date: date that the annotation was created;

–	description: the content of the annotation.

### 8	Functional capabilities of web objects based uSDL

The attributes of educational content objects will characterize functional capabilities of uSDL_VOs in the web objects based uSDL. In the layered architecture of web objects based uSDL, uSDL_CVOs and uSDL service entities are abstracted by multiple uSDL_VOs. Thus, the functional capabilities of web objects based uSDL in clauses 8.1, 8.2 and 8.3 will be characterized by the features of attributes in clauses 7.1 and 7.2.

### 8.1	Layered architecture of web objects based uSDL

The layered model for web objects defines the main abstractions and concepts that underlie the web objects domain and describe the relationships among educational real world objects (e.g., educational contents, physical devices, equipment), virtual objects (VO and CVO) and uSDL services as described in [ITU-T Y.4452]. Web objects are meant to extend the web from the physical world to the virtual world, to involve interaction with physical entities in ambient environments. These abstractions and concepts include the following:

–	real world learning objects that could be a source of information related to resources, contents or devices. The information consist of the specific attributes of web objects based uSDL;

–	a uSDL VO that is capable of inheriting properties and attributes as an instance extracted from educational real world objects;

–	a uSDL CVO that is composed of multiple education VOs;

–	a uSDL service level that interacts with VOs and CVOs in accordance with the processes being executed within the uSDL service function.

Objects introduced in the web objects based uSDL environment are frequently reused, reconfigured and recreated to adapt to diverse applications environment in accordance with users' requirements. Several objects, each with its own attribute values and its virtualization function in the web objects based uSDL environment, can be used to create another new service resulting in the creation of an original object.
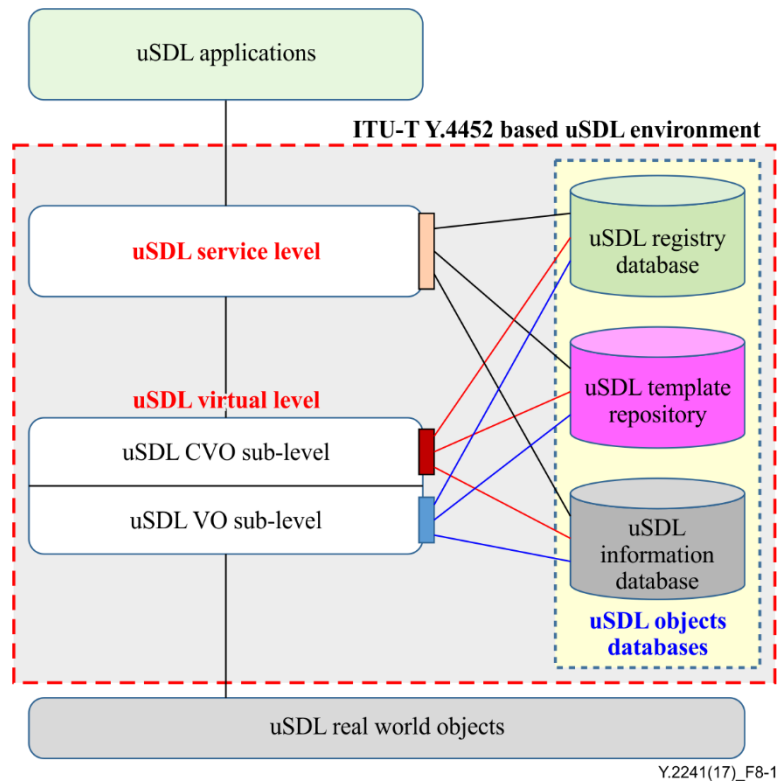
**Figure 8-1 – Layered architecture of web objects based uSDL
(in accordance with [ITU-T Y.4452])**

Figure 8-1 shows the layered architecture for web objects based uSDL in accordance with [ITU-T Y.4452]. The objects levels in the web objects based uSDL platform have different specified attributes of their own. For example, some particular attributes of the CVO are characterized by multiple VOs with different attributes extracted from real world objects. A uSDL service function is abstracted from multiple CVOs. A uSDL service function of web objects based uSDL is organized through the creation of a relationship between learning procedures, learners and the uSDL content objects.

The uSDL service provisioning is modelled as shown in Figure 8-2, and its model is consistent with the layered architecture shown in Figure 8-1. A uSDL learning application chosen by a learner is composed of one or multiple uSDL service components to perform the required service functions. A service function is abstracted through the harmonization of one or multiple CVOs to retain the learner motivated education information in accordance with their own contents database through the functions of the group of uSDL VOs. Thus, Figure 8-2 shows a layered model that performs the abstraction and harmonization of uSDL content VOs/CVOs for the selection of a uSDL learning application.
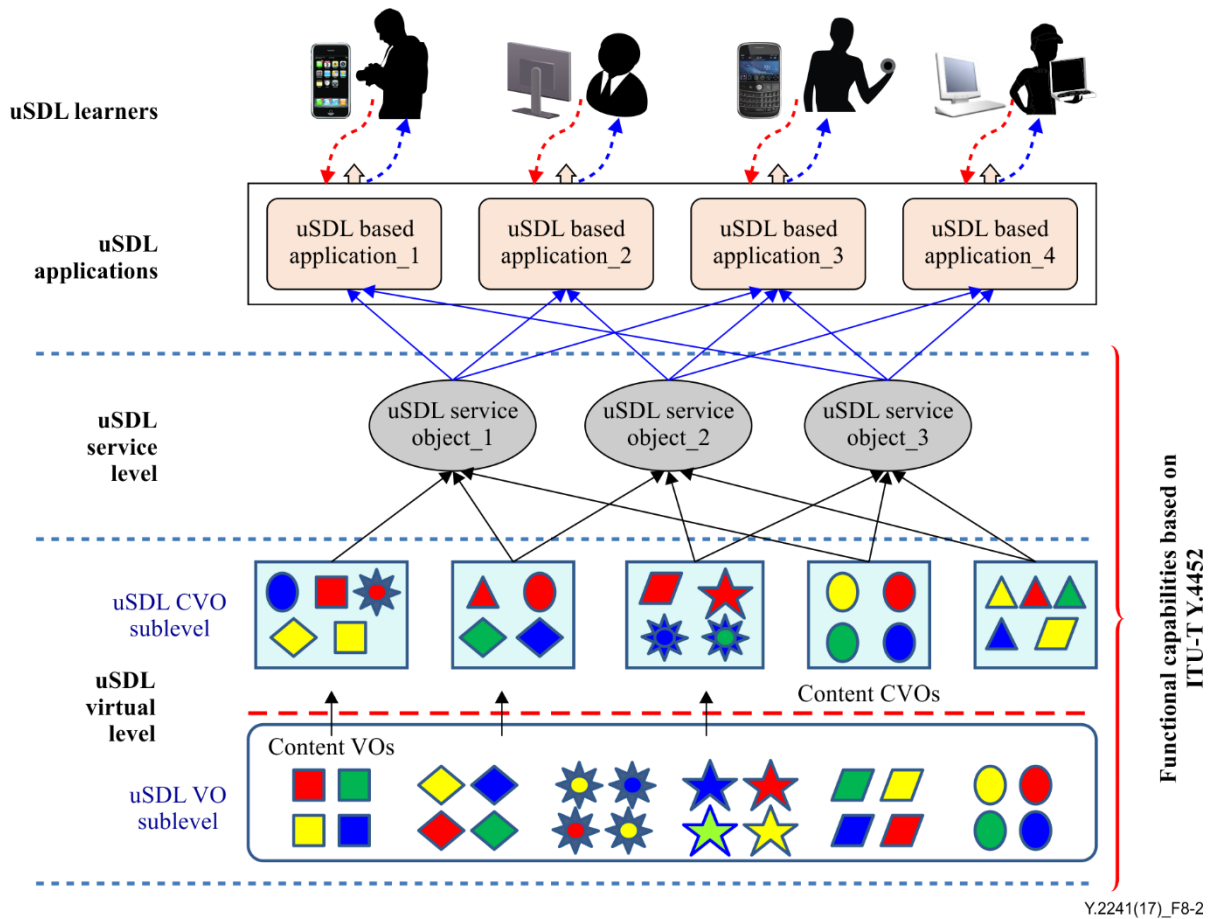
Figure 8-2 – A harmonization and abstraction model to support web objects based uSDL service

8.2 Functional capabilities of web object based uSDL virtual level

The contents model in uSDL is depicted through the features of contents objects from an educational service perspective. As shown in Figure 8-3, the object element should be published in the ontology repository where it is to be consulted by learners.
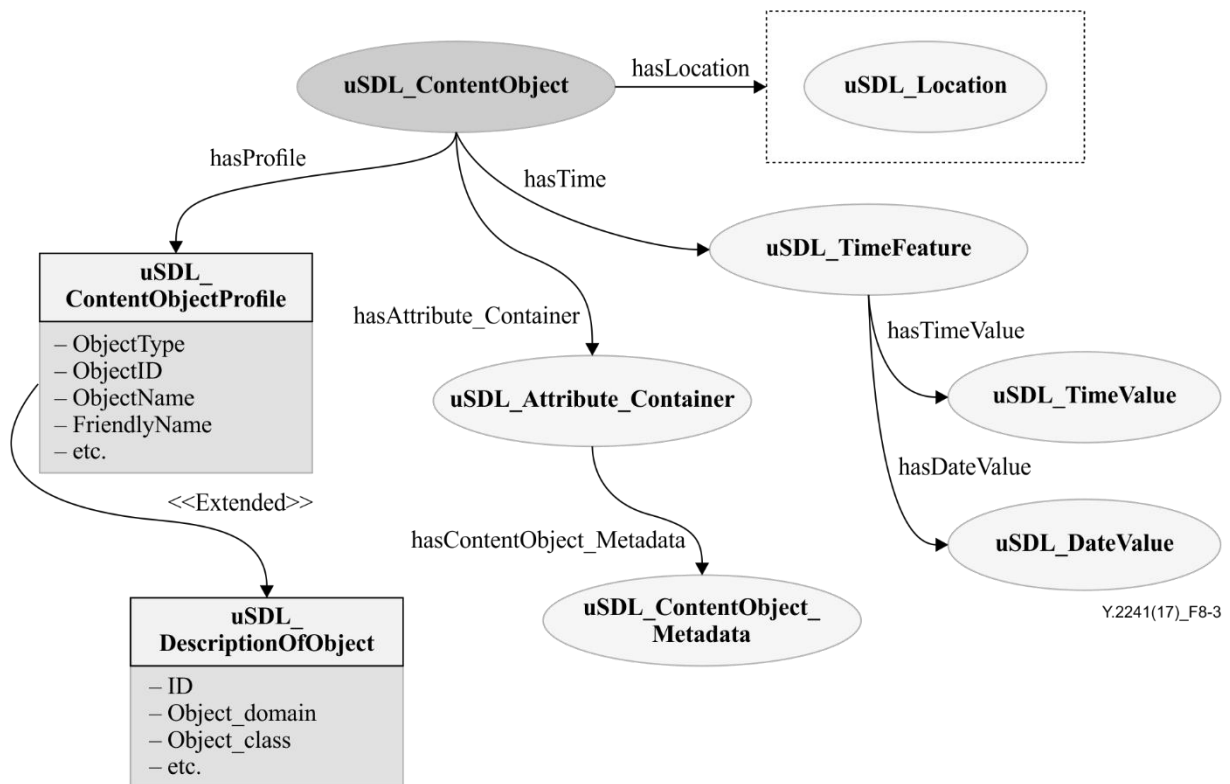
Figure 8-3 – Content object model for uSDL

The content model structure of uSDL comprises of the following elements: DescriptionOfObject, uSDL_ContentObjectProfile, uSDL_AttributeContainer, uSDL_ContentObjectMetadata, uSDL_TimeFeature and Location, where:

– uSDL_ContentObjectProfile consists of information that could support the profile of content in a uSDL environment;

– uSDL_Location has the same identical model that is used for the location of the resource in a uSDL environment;

– uSDL_TimeFeature indicates the time and the date specified as TimeValue and DateValue of uSDL;

– uSDL_AttributeContainer contains one or more contents of the object of uSDL;

– uSDL_ContentObjectMetadata specifies the detailed information that is used to define the data information stored in the attribute_container of uSDL;

– DescriptionOfObject is the extended profile information that is needed and which supports uSDL.
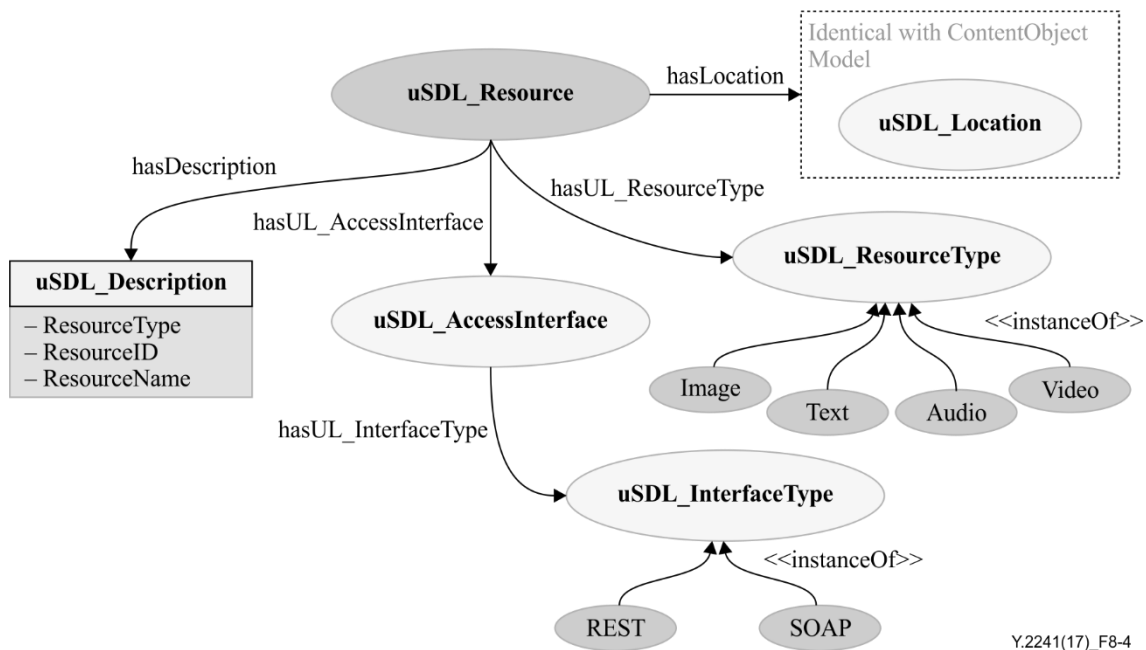
Figure 8-4 – Resource model in the web object based uSDL environment

The resource model for uSDL, shown in Figure 8-4, represents the details and related data in the digital world. This model provides the core components of related data to provide efficient and effective decision making to support the content object model. The model is composed of:

– uSDL_Location has the same identical model that is used in the content object model of the web object based uSDL;

– uSDL_ResourceType specifies the service that the image, text, audio and video that could provide information, and link to the resource type in web object based uSDL environment;

– uSDL_AccessInterface gives an access to the interface that specifies what technology interface is to be used in the uSDL_InterfaceType;

– uSDL_InterfaceType further specifies the set of instances that reflects the interface technology which are provided in the web object based uSDL;

– uSDL_Description indicates the information that could support the resource model for uSDL.

The VO sub-level is formed with a single specific attribute from another single real world object, and later multiple virtual objects are formed with similar attributes from their respective real world object, to be handed to the CVO sub-level as shown in Figure 8-5.
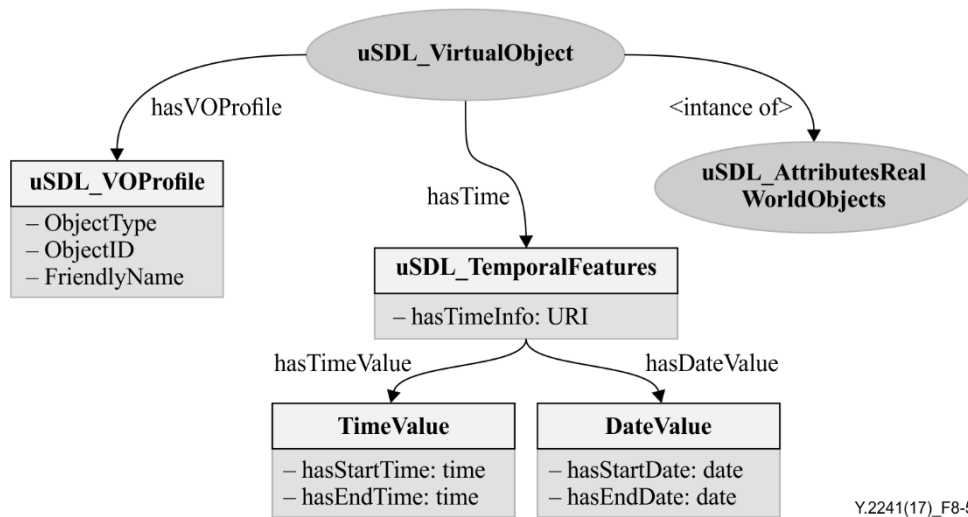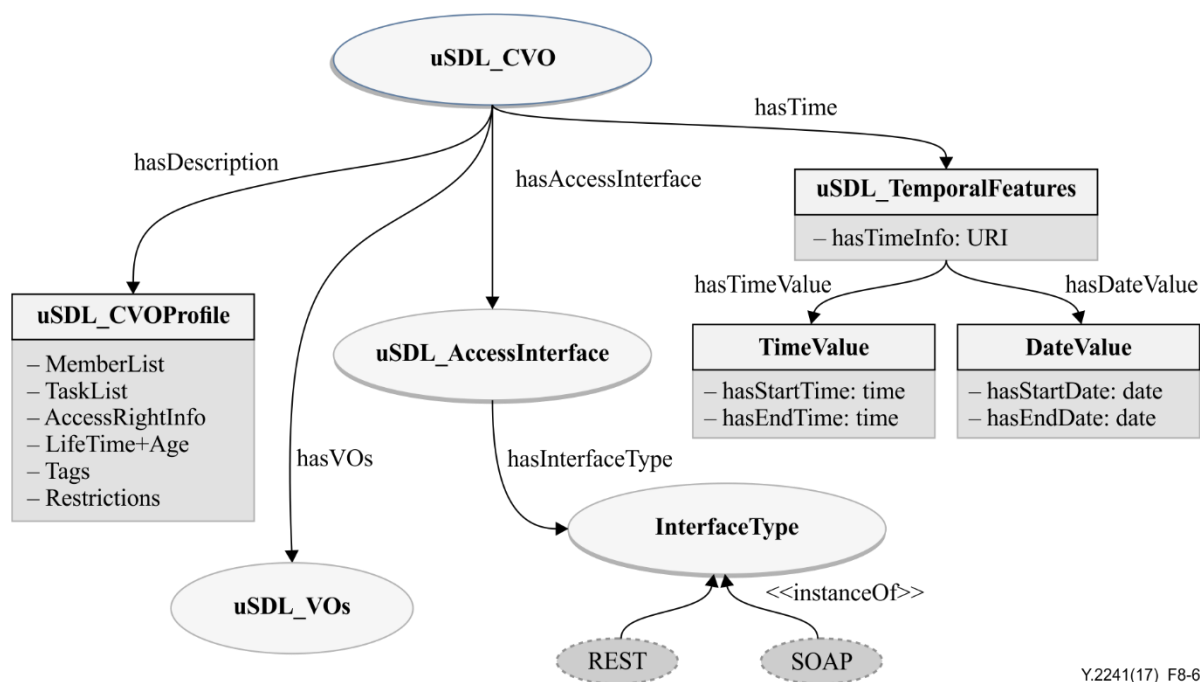
Figure 8-5 – Information model of web object based uSDL VO sub-level

The elements of the model described in Figure 8-5 are as follows:

– uSDL_VOProfile of uSDL contains details which are used to identify the virtual uSDL object;

– uSDL_TemporalFeatures for uSDL have its sub portions that indicate time and data related information of uSDL;

– uSDL_AttributesReaWorldObjects includes information of real world objects in the uSDL environment.

The CVO sub-level is composed of multiple virtual objects that will be delivered to the service domain, see Figure 8-6. The CVO sub-level in uSDL provides the following composition of attributes appointed by multiple virtual objects to be used for a desired service components:

– uSDL_CVOProfile contains details to identify the composite virtual object (CVO);

– uSDL_TemporalFeatures, which has a part that indicates time and data related information, similar to the functionality of the virtual object;

– uSDL_AccessInetrface.

Figure 8-6 – Information model of web object based uSDL CVO sub-level

Appendix I shows an example of the content objects model for web objects based uSDL. The uSDL content objects depicted in Appendix I is based on the information model of VO/CVO shown in Figures 8-5 and 8-6. Figure II.1 (example of a metadata for uSDL objects) indicates examples of uSDL_VOProfile and uSDL_CVOProfile shown in Figures 8-5 and 8-6.

8.3 Functional capabilities of web objet based uSDL service level

The service level provides different combinations of objects from the virtual level in order to compose a necessary service in different forms. It may take up objects whether they be virtual objects or composite objects to create a suitable service provision. The web objects based uSDL service level is characterized by the following properties:

– uSDL_ServiceDescription: includes information to identify the service name, identifier and serviceCategory;

– uSDL_ServiceType: the service explanation of modelling language type technique;

– uSDL_ServiceProfile: The profile of service, range of service, schedule, input and output, precondition, effect and other related information are included. Also, the connection of each of the devices to the ValueContainer in a device model.

The service model of web objects based uSDL is denoted with the relationship among learner, objects to provide educational contents and system resources. This allows the learner to review the learning section with resources which are openly offered on the web, and according to the users' selection.

The following are characteristics of web objects based uSDL description features:

– the educational objects are provided through the web with open forms of content objects;

– the various content objects could be simultaneously access capable, and even though changes may occur due to the time alteration they will adjust and continue to provide the service;

– the same content objects are provided to the users, but customized uSDL service could be provided according to the requirements or characteristic of the users;

– the information of content object has the scalability and large ripple effect to enhance the utilization and usefulness from the updated available information;

– the just-in-time learning service could be provided in any place according to the user's environmental location and the device terminal;

– web objects based uSDL service has the capability to have interaction between the content objects that are collected from the user and the lecturer. It allows them to collaborate and cooperate by sharing knowledge and information, and can therefore be used to increase the performance of learners.

In order to produce the optimized and customized service of web objects based uSDL service in a ubiquitous environment, semantic elements are needed to provide intelligent service that collects and analyses the specific circumstance of a user's multiple environments.

To describe the semantic profile of services description in web objects based uSDL, the uSDL service is modelled by its ontology. The service may have several descriptive properties such as input and output pre-condition and effect (post condition), and additionally it may also include non-functional properties such as quality of service, service level agreement (SLA), etc.
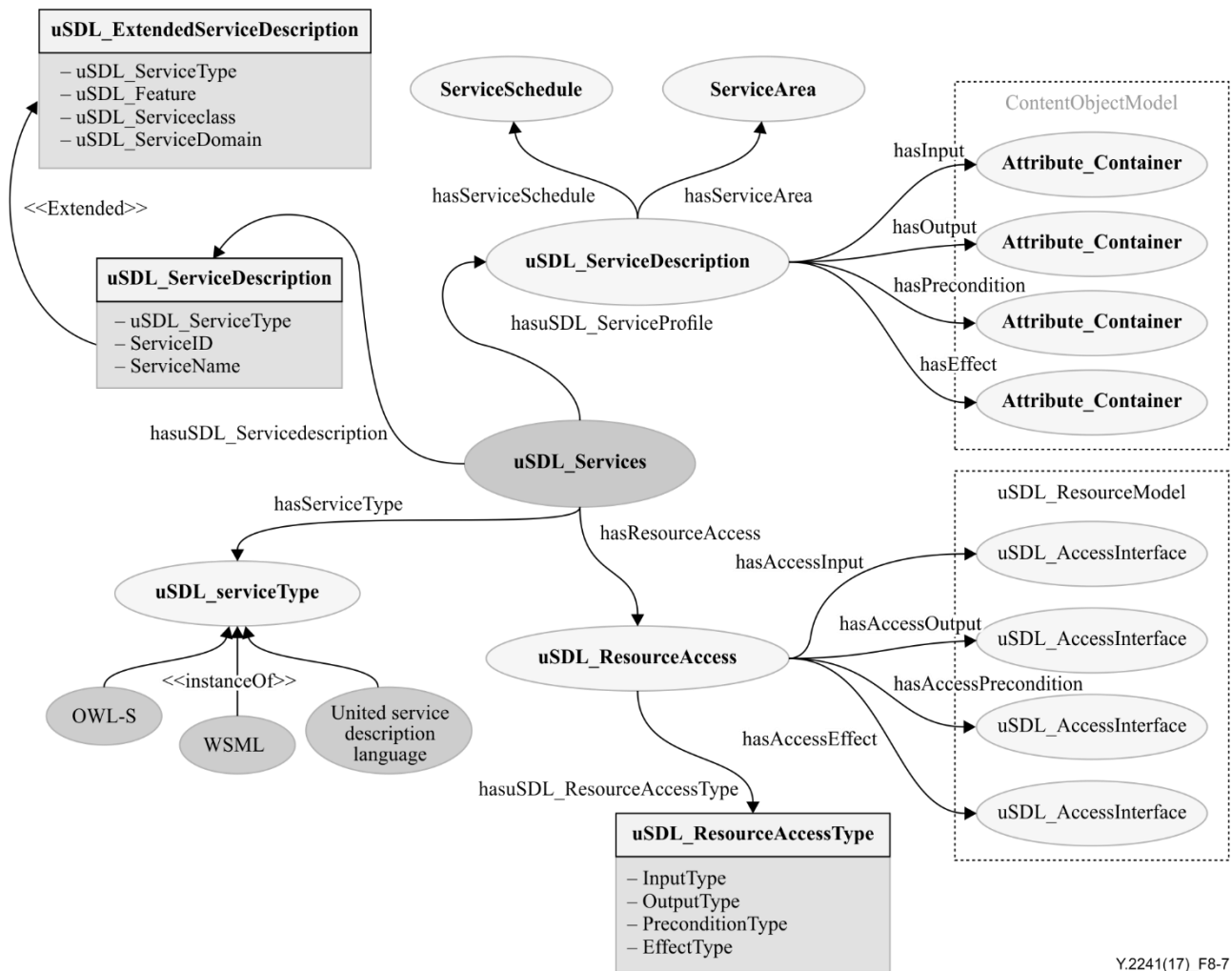

Figure 8-7 – Information model in web objects based uSDL service level

The service model of web objects based uSDL shown in Figure 8-7 contains well-defined and standardized interfaces, offering all the necessary functionalities for interacting with content objects and related resources. The services expose the functionality of uSDL content objects by accessing its hosted resources.

The model depicted in Figure 8-7 is a service semantic ontology model used to provide ubiquitous learning service in web objects based uSDL environment. Indicating one service means that

interoperable contents are provided in the service model, while the service model itself defines each of the available contents for interconnection. Also by including the information of the mapped resource model with the contents model, the needed access interfaces of content objects are provided during service provision.

In order to provide semantic ontology based uSDL_services, the appropriate resource information can be accessed. As the resource service is mapped with content objects, based on resource information the appropriate contents are capable of being controlled and managed.

The Service model is composed of four top properties as shown in the following description:

–   uSDL_ServiceDescription: include the definition of the uSDL service, and uSDL service is also included as extension;

–   uSDL_ServiceType: the service explanation of the modelling language type technique;

–   uSDL_ServiceProfile: the profile of service, range of service, schedule, input and output, precondition, effect and other related information are included also, the connection of each contents of uSDL to the ValueContainer in the content object model;

–   uSDL_ResourceAccess: contains the information to access the information type and resource in approaching the resource model. It is connected to the AccessInterface.

Figures II.1 and II.2 show use cases of the above functional capabilities of uSDL service level, and provides intelligent and situation/context awareness features in the web objects based uSDL environment in accordance with the capabilities of clause 8.3.

9   Security support for web object based uSDL environment

There are security threats and challenges when the contents objects of web objects based uSDL communicate with each other. Its security requirements vary to a great extent for different ubiquitous networking applications. The contents objects in uSDL have their own identities (e.g., URI) and their inter-communication in a dynamic and heterogeneous environment requires more interactivity. Accordingly, it is crucial that secure information discovery and secure information delivery to users (including persons and uSDL contents objects) be carefully considered in the design of security framework.

Based on the security threats and challenges indicated in [ITU-T X.1314], the security support for web objects based uSDL environment will be in line with the guidelines and principles described in [ITU-T X.1314].

10   Trust provisioning

uSDL will share the educational contents among learners. With a trust arrangement, a learner may take the contents from others and legitimately share that content with other learners. A trust provisioning among learners will need to guarantee the trustworthy sharing of educational uSDL contents. The trust value would be used to judge whether a learner has enough authorization to get the contents or not in the uSDL environment.

Trusted content collection and aggregation in web objects based uSDL environment will include the features to support trustworthy relationship among persons (e.g., learners and teachers) and the uSDL contents. In this case the friendship relationship among educational contents and participants (e.g., learners and teachers) will be considered to characterize the cooperativeness in the community of interest (COI), ownership and trust management.

Appendix I

Example of educational content object model in web objects based uSDL

(This appendix does not form an integral part of this Recommendation.)

A semantic ontology based educational content object will be created based on the information of various content attributes. When objectifying the content, different users in the uSDL environment are able to provide and to be provided with new services by combining or using objects. Figure I.1 shows the content objects model for web objects based uSDL.
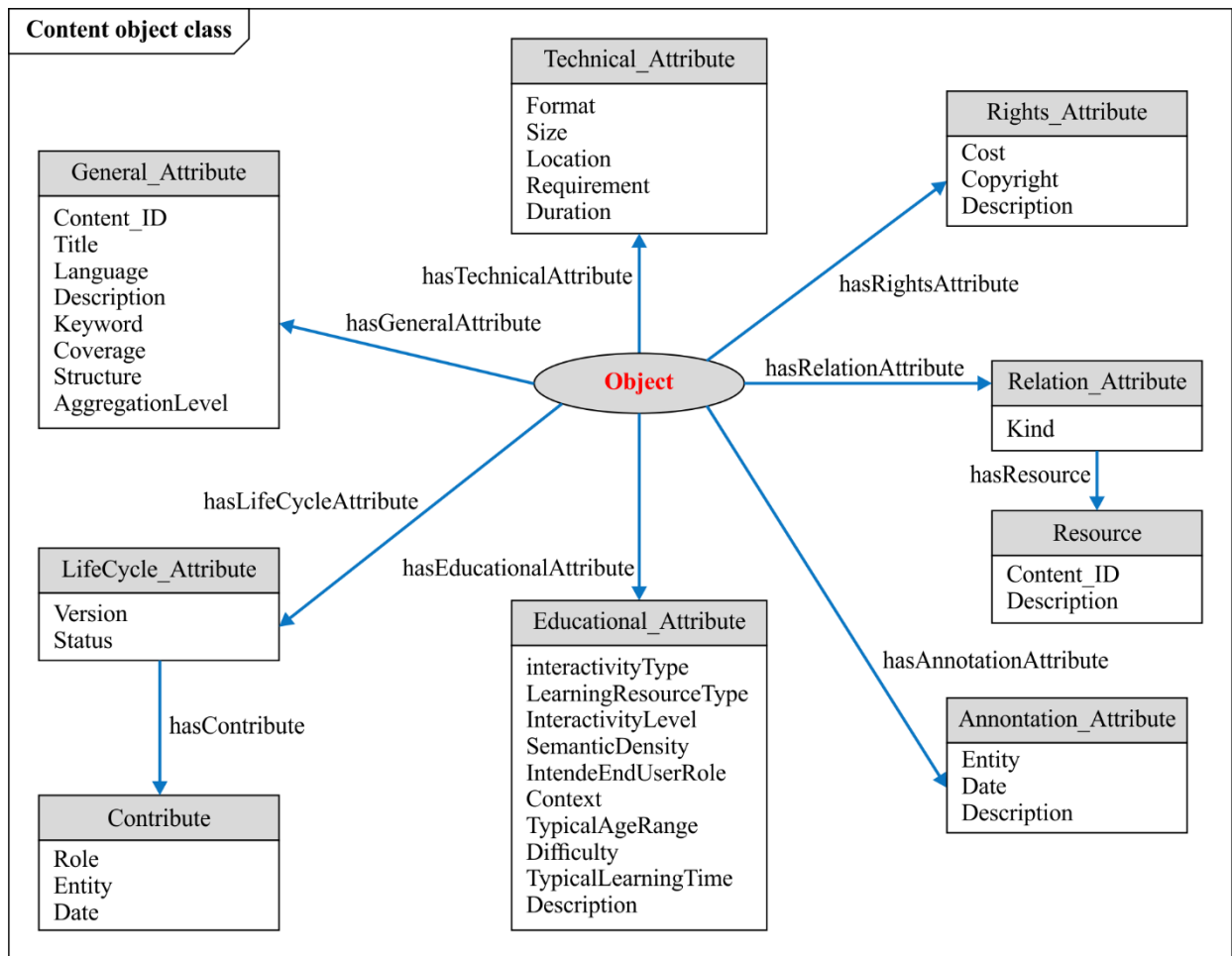
Figure I.1 – An example of content objects model in web objects based uSDL

In the structure shown in Figure I.1 the generated content objects are again combined with the other objects to create new objects (VOs/CVOs), and so various objects combine with each other to provide and form new uSDL services.

Appendix II

Example of an architecture to support smart uSDL entity perspectives

(This appendix does not form an integral part of this Recommendation.)

II.1 LOM approach for notation of uSDL

The application of educational metadata is nowadays often limited to the description of static resources (text or image) in order to support the retrieval process. The usage of metadata is done in a static way with respect to the (static) content and cannot influence multimedia content itself. An adequate description of dynamic multimedia content, for example animations, is also difficult.

A web objects based uSDL will use a dynamic educational metadata as an extension of IEEE's learning objects metadata (LOM) to describe the multimedia content. These metadata can be used to customize the behaviour of the multimedia object according to the user's needs. The term customization is normally used in the context of the component software technology and applied in the context this Recommendation to denote changes and/or modifications to a multimedia learning object. These changes are necessary to match the learning goals of a user and to reuse the dynamic multimedia content in a different context.

A LOM is a data model, usually encoded in an extensible markup language (XML), used to describe a learning object and similar digital resources used to support learning. The purpose of the learning object metadata is to support the reuse of learning objects, to aid discoverability, and to facilitate their interoperability, usually in the context of online learning management systems (LMS). Some of the main things that the LOM is designed to help achieve are:

– Creation of well-structured descriptions of learning resources to help facilitate the discovery, location, evaluation and acquisition of learning resources by students, teachers or automated software processes.

– Sharing of descriptions of learning resources between resource discovery systems, which should lead to a reduction in the cost of providing services based on high quality resource descriptions.

– Tailoring of the resource descriptions to suit the specialized needs of a community, which may include choosing suitable controlled vocabularies for classification, reducing the number of elements that are described or adding new ones from other resource description schemas.

Creators and publishers may use the LOM along with other specifications to "tag" learning resources with a description that can be associated with the resource, providing information in a standard format similar to that found on the cover and fly-page of a text book.

Learning object metadata is a recognized open format for the description of "learning objects". Relevant attributes of learning objects to be described include: type of object, author, owner, terms of distribution, format and pedagogical attributes such as teaching or interaction style.

II.2 VO/CVO based description of learning object metadata in uSDL

An example of the general structure of the dynamic metadata category extending the base LOM scheme is shown in Table II.1. It should be noticed that the LOM base scheme has already introduced some fields which are similar to the ones described in Table II.1.

Table II.1 – Example of metadata for uSDL objects

Property	Description	Example
1. Code information	**Information concerning the code of the Smart_Learning_Object (SLO).**	
1.1 CodeName	• The name of the start code of the SLO.	• a.class, a.flash, etc.
1.2 CodeLocation	• Denote where the SLO located.	• URI
1.3 CodePackage	• The name of the package or zip of SLO.	• a.jar, a.zip, etc.
2. Presentation information	**The information concerning how the SLO is to be presented.**	
2.1 Language	• The language the SLO should start with.	• en, de, fr, etc.
2.2 DifficultyLevel	• The degree of difficulty the resource should start with.	• Very low, low, normal, high, very high
2.3 InteractiveLevel	• The degree of interactivity of the resource.	• Very low, low, normal, high, very high
2.4 Dimension	• The 3 dimensions information of the visualization with.	• x, y, z
2.5 Bidirectional	• Indicates whether the explanation, visualization can be done in the back direction or not.	• yes, no
3. Topic information		
3.1 Topic	• The name of the topic to be shown by the resource.	• FIFO, earliest deadline first....
3.2 Scenario	• The name of the scenario to be visualized by the resource.	–
3.2.1 Mode	• Intention of the teacher with regards to the SLO.	• Problem, solution, normal, guidedTour
3.2.2 Name	• Stores the name of the scenario.	• Collision, shortframe
3.3 Input data	• The name of the input file needed by the resource input file need by.	• Parameters.txt
3.4 Output data	• The name of the output file the resource should generate.	• Parameters.txt
4. Explanation information	**Indicates which kind of explanation is required for the smart learning object.**	
4.1 Type	• A list of possible explanation types.	• Information, warning, error, log, hint
4.2 Media	• A list of possible media types to be used for the explanation.	• Text, audio, video

Y.2241(17)_Table II.1

Figure II.1 shows an example of the architecture on object tagging and customization of smart uSDL objects based on VO and CVO in educational materials. For instance, for the storage of static and dynamic metadata, a relational database (e.g., resource description framework (RDF), Ontology, VO/CVO) will be used to construct a web objects based uSDL environment. As indicated in Figure II.1, the WoO platform [ITU-T Y.4452] will support a web environment for dynamic and static metadata processing, and will create a self-directed smart learning service.

In order to support "educational objects customization", a content customizer is used to provide the smart uSDL program and allows it to create features equivalent to LOM features. In the visualization scenarios, smart featured user interface/user experience (UI/UX) will also be supported through the customer devices.
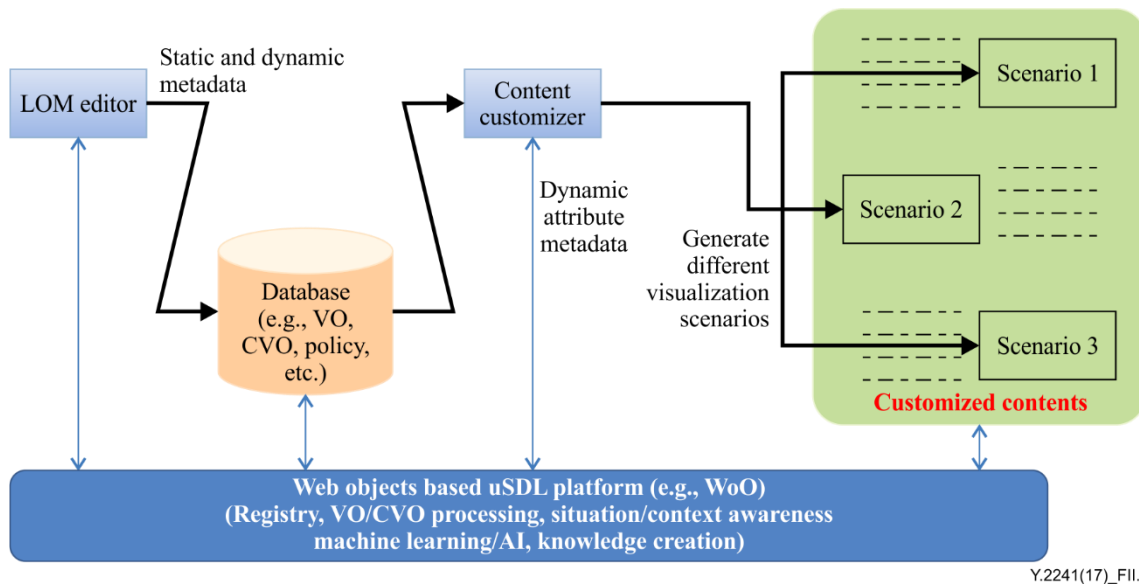
Y.2241(17)_FII.1

**Figure II.1 – An example of the architecture on object tagging and customization
of smart uSDL objects**

Based on the descriptions of clauses 7 and 8 and Figure II.1, the operational procedure of web objects based uSDL system is shown in Figure II.2. The management functions for service, uSDL CVO and uSDL VO performs the control and management functions to support uSDL educational service capabilities. In order to provide personalized and intelligent features in web objects based uSDL environment, the enhanced capabilities of situation/context awareness, machine learning and artificial intelligence (AI) will be performed.
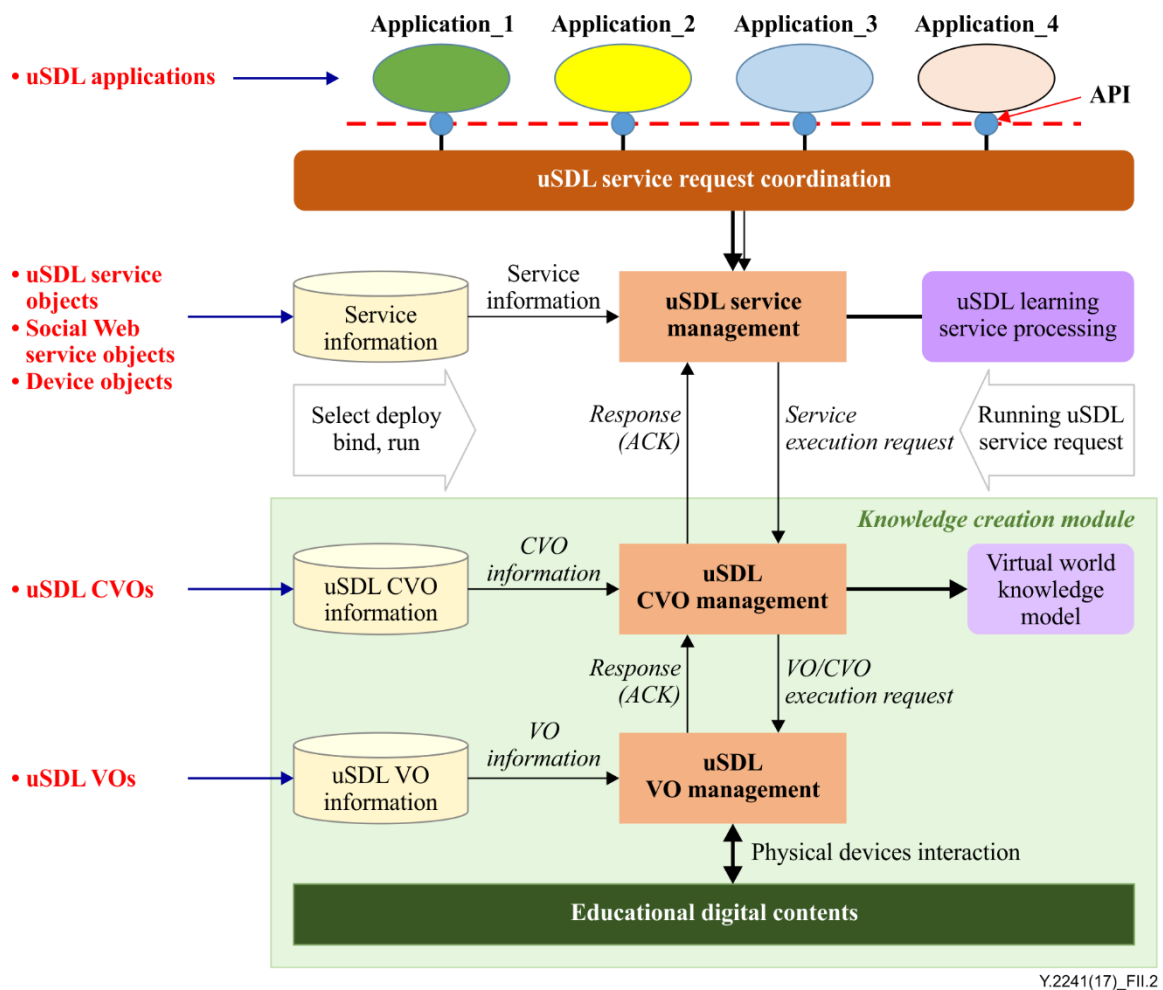
Figure II.2 – Service procedure of web objects based uSDL system

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