Designing Learning Systems to Provide Accessible Services

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ABSTRACT

The need for providing learners with web-based learning content that match their accessibility needs and preferences, as well as providing ways to match learning content to user's devices has been identified as an important issue in accessible educational hypermedia literature. Several initiatives already exist trying to provide accessible web-based learning environments addressing a broad range of access needs and requirements. However, the design and development of web-based learning environments for people with special abilities has been addressed so far by the development of hypermedia and multimedia based educational content that is specially designed for the user targeted group, as well as the use of dedicated infrastructure supporting the delivery of learning content. Such approaches not only prevent their user groups (learners and their tutors) from accessing other available resources, but also keep them dependent from the specific e-learning platform, since the supported hypermedia content and learning scenarios are a-priori designed for the targeted user group. In this paper we address the need for an architectural definition of a web-based learning system that satisfies the design steps and requirements identified following the current state-of-the-art accessibility approaches and techniques, as well as the need to define an accessibility application profile for enabling the formalization of learning object accessibility properties, in order to match learning content with learner accessibility preferences.

Categories and Subject Descriptors

K.3.1 [**Computers and Education**]: Computer Uses in Education – *Distance Learning.*
D.2.11 [**Software Architectures**]: Domain-specific architectures.

General Terms

Design, Standardization.

Keywords

Accessibility, Architectures, Accessibility Application Profiles, Learning Design.

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1.INTRODUCTION

During the last years, accessibility has been recognized as one of the main design requirements for web-based content and systems [1, 2]. In the eLearning sector several systems already exist trying to address the need of providing access to learning material for people with a broad range of access needs and requirements. Such systems include among others the HOPE [3], the LINK [4], the VisiCAST [5], the SMILE [6] and the EVIDENT [7].

The design and development of web-based learning environments for people with special abilities has been addressed so far by the development of hypermedia and multimedia based educational content specially designed for the user targeted group, as well as the use of dedicated infrastructure supporting the delivery of learning content. The main drawback of this approach is that content can be delivered only through the dedicated e-learning platform, thus limits the capability of reusing and repurposing learning content. On the other hand, even if an open and scalable learning environment has been implemented, the supported content and learning scenarios are a-priori designed for the targeted group. As a result, the user group (learners and their tutors) is prevented from accessing other available resources and is also fully dependent from the specific e-learning platform [8].

In this paper we address the need for an architectural definition of a web-based learning system that satisfies the design steps and requirements identified following the current state-of-the-art accessibility approaches and techniques, as well as the need to define an accessibility application profile for enabling the formalization of learning object accessibility properties, in order to match learning content with learner accessibility preferences.

The paper is organized as follows: In section 2 we discuss the accessibility dimensions in web-based learning, aiming to identify the main design considerations for accessible web-based learning systems. For each accessibility dimension we analyse the accessibility requirements, present the state-of-the-art accessibility approaches and techniques and discuss the open issues concerning web-based learning systems design. Section 3 presents an architectural definition of a web-based learning system that addresses the design steps and requirements identified following the current state-of-the-art accessibility approaches and techniques. Section 4 discusses the need for defining an accessibility application profile in order to formalize learning object accessibility properties, and to enable matching

learning content with learner accessibility preferences. We present a methodology for defining such an application profile based on the accessibility dimensions identified. Finally, we present an accessibility application profile of the IEEE LOM standard produced as a result of the above described process.

2.THE DIMENSIONS OF ACCESSIBILITY IN WEB-BASED LEARNING

2.1Designing Accessible Web-based Learning Systems

During the last years, e-learning has attracted a great attention from both academia and industry. However, only recently the issue of accessibility in e-learning systems has emerged. Accessible learning systems are systems that provide accessible *learning content* through accessible *interfaces*. In the case of Web-based Learning Systems, learning content has the form of hypermedia objects (also called learning objects). Accessible browsing interfaces in this case, are web browsers or interface applications supporting assistive technologies, e.g. screen readers or Braille displays. Thus, the process of designing accessible web-based learning applications involves two main actions, namely:

- Designing accessible hypermedia based learning content.
- Designing accessible interfaces for browsing this content.

Figure 1, presents the accessibility dimensions and design processes of web-based learning systems.

In order for a content developer to design accessible hypermedia and for a system designer to design accessible interfaces, several steps should be followed. The first step is the *identification of the target user group accessibility needs*. This process should be based on the use of best practice guides and/or guidelines that relate disability categories with design requirements.

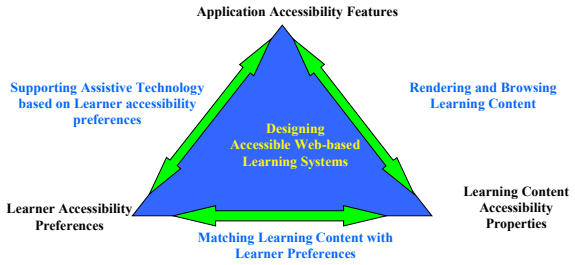

Figure 1: Accessibility dimensions and design processes of web-based learning systems.

The second step is to *identify learning object accessibility properties*. The accessibility needs or preferences for the target audience and the accessibility properties of the learning objects should be formalized in standardized descriptions (information models) in order to enable the matching of learning content with learner preferences. The formalization of those information models will act as a script to the web-based learning system in order to offer accessible services and at the same time enables reusability of both content and learner information across systems. The third step of the design process includes the design of the *learning system's accessibility features*. The definition of those features should be based on the design requirements identified at the first step (Identification of Learner Accessibility Preferences).

After defining the accessibility features of the learning system the designer should address the following questions:

- What is the appropriate assistive technology related to learners' accessibility needs?
- What specific content design techniques should be followed in order to ensure the appropriate rendering and to enable browsing of the content?

2.2Open Issues and Current State-of-the-Art

As we already described, the design of accessible web-based learning systems is defined upon three dimensions.

2.2.1. Learner Dimension

This dimension includes the identification of learner accessibility preferences and the modeling of those preferences into reusable information records. This process can be based on the use of the IMS Learner Information Package (LIP) specification [9] or any other learner modeling specification. The IMS LIP specification provides the means to "package" learner information. Regarding accessibility, IMS LIP information model includes the "accessibility" element that describes learner accessibility information. Figure 2 presents the information structure of the IMS LIP accessibility element. The accessibility information is defined through the description of the following learner's characteristics:

- Language Capabilities, that is, the definition of learner's language proficiencies;
- Disabilities, as to what the learner is no able to do;
- Eligibilities, as to what the learner is able to do;
- Preferences, including learning preferences (e.g. issues of learning style), physical preferences (e.g. a preference for large print) and technological preferences (e.g. a preference for a particular computer platform).

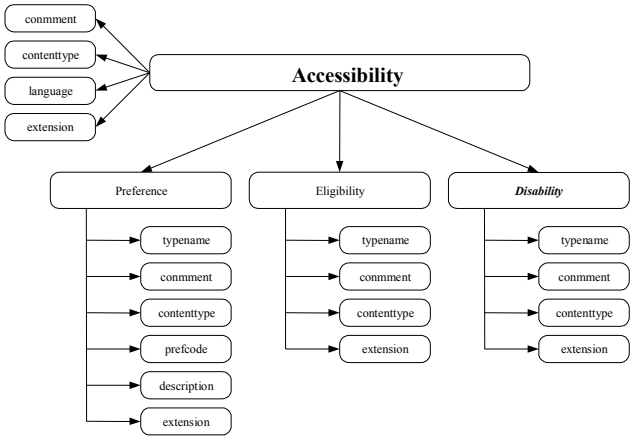

Figure 2: Accessibility element of IMS Learner Information Package

An extension to the IMS LIP information model is the IMS Accessibility for LIP Information Model (AccLIP) specification [10], published on July 2003. This specification defines accessibility preferences that were left for future work in the IMS LIP and provides a description of how learners prefer to interact with an online learning environment. IMS AccLIP extends IMS LIP information related to learner accessibility preferences through the definition of display, control and content preferences. Figure 3 presents the information structure of the IMS AccLIP accessForAll element.

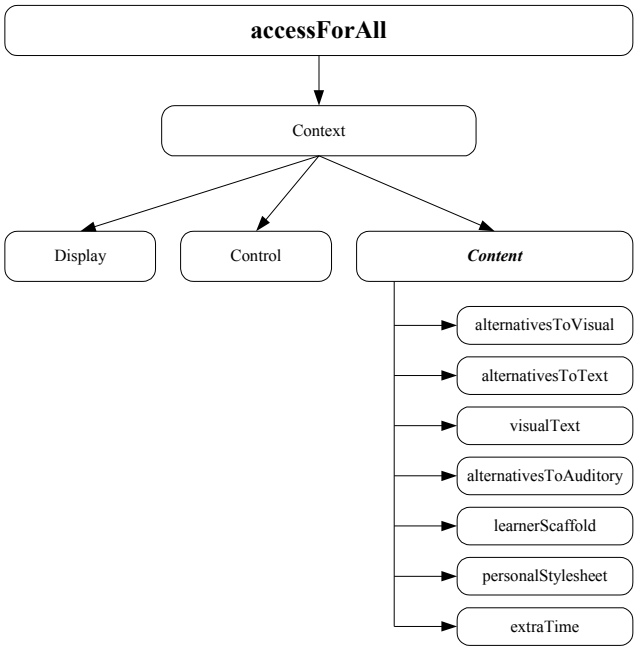

Figure 3: Content specific information in IMS Accessibility for LIP Information Model

Even though an analytic information model for representing learner accessibility preferences exists (IMS LIP and IMS AccLIP), there are several open issues in respect with learner accessibility dimension, including the mapping of assistive technology to learner preferences and the translation of learner accessibility preferences to system design requirements.

2.2.2. Content Dimension

This dimension includes the identification of design techniques and requirements that should be followed in order to design accessible hypermedia, as well as the identification of learning content accessibility properties and the modeling of those properties into reusable information records. This process can be based on the use of the W3C Web Content Accessibility Guidelines (WCAG) [11]. These guidelines explain how to use web technologies in order to design and develop accessible hypermedia. The guidelines consist of checklists based on three priority levels, namely:

- Priority 1 checkpoints. These checkpoints set the mandatory accessibility requirements for hypermedia development.
- Priority 2 checkpoints. These checkpoints set the suggested accessibility requirements for hypermedia development.
- Priority 3 checkpoints. These checkpoints set the optional accessibility requirements for hypermedia development.

In order to follow and/or test the hypermedia content against the above described requirements of the W3C WCAG, several tools already exist. They can be classified in three main categories, namely:

- *Evaluation tools.* These tools perform a static analysis of hypermedia regarding their accessibility, and return a report or a rating. Validation tools that check HTML and CSS without an accessibility focus can also be included, since validating to a published grammar is one step towards accessibility. Examples of such tools include the AccessEnable [12], AccVerify [13], Bobby [14], DrWatson [15] and RAMP [16].
- *Repair tools.* Once the accessibility issues have been identified, these tools can assist the author in making hypermedia more accessible. Examples of such tools include A-Prompt [17], AccRepair [18], Hi-Caption [19] and InFocus [20].
- *Filter and transform tools.* These tools modify hypermedia content or supplement an assistive technology or browser. Some of these tools integrate into the browser although most of them work by proxy, that is, using a piece of software that sits between the user and the target server to transform hypermedia content in order to make it more accessible. In some cases the tools are designed for users to enhance their personal setup. In other cases, they are designed for content providers to provide content services appropriately customized for the device in-hand. The second process is similar to what is done by systems that provide web services or information services adapted to several delivery contexts, such as mobile devices. Examples of such tools include Altifier [21], Web page Purifier [22] and WebCleaner [23].

The identification of learning content accessibility properties and the creation of a model for representing accessibility information for learning resources remains an open issue. Several initiatives already exist trying to define a metadata model for representing accessibility information for learning resources, including the CEN/ISSS Learning Technologies Workshop Accessibility Working Group [24], the Dublin Core Metadata Initiative (DCMI) Accessibility Working Group [25] and the IMS Accessibility Working Group [26].

2.2.3. System Dimension

This dimension includes the definition of system's accessibility features along with the required assistive technology that the system should support. This process can be based on the use of the IMS Guidelines for Developing Accessible Learning Applications [27]. Those guidelines include several design requirements concerning:

- Flexible media delivery of text, audio, images and multimedia

- Developing asynchronous and/or synchronous communication and collaboration tools
- Developing accessible interfaces and interactive environments
- Testing and assessment

In the system dimension, there are several issues to be addressed including the separation of content from the delivery platform, enabling content interoperability across different systems, as well as the separation of content information from content presentation, so as to enable rendering to a diverse set of devices with different layout capabilities and/or requirements.

Summarizing the open issues, there is a need for an architectural definition of a web-based learning system that addresses the design steps and requirements already identified based on the current state-of-the-art accessibility approaches and techniques, as well as the need to define an accessibility application profile for enabling the formalization of learning object accessibility properties, and the matching of learning content with learner accessibility preferences.

3.AN ARCHITECTURAL APPROACH SUPPORTING ACCESSIBLE HYPERMEDIA

The design and development of web-based learning environments for people with special abilities has been addressed so far by the development of hypermedia and multimedia based educational content that is specially designed for the user targeted group, as well as the use of dedicated infrastructure supporting the delivery of learning content. The main drawback of this approach is that content can be delivered only through the dedicated learning platform, limiting the capability of reusing and repurposing learning content. On the other hand, even if an open and scalable learning environment has been implemented, the supported content and learning scenarios are a-priori designed for the targeted group, preventing the user groups (learners and their tutors) from accessing other available resources and keeping them dependent from the specific e-learning platform.

The proposed approach addressed in this paper aims to separate hypermedia content from the required specially designed for people with special needs training processes and/or the corresponding special equipment or assistive technology. Such an approach defines accessibility in a broader fashion than "providing accessible content to people with disabilities", thus, enabling access for all to the same information resources.

Moreover, the support of hypermedia designed based on requirements for different target user groups, indicates that the proposed architecture approach is generic enough to enable a web-based learning system acting as a rendering device driven by the underlying pedagogy independently from the learning content to be delivered. The separation of information from presentation features in the hypermedia content, gives the flexibility to support individualized presentation styles based on learner accessibility preferences, as well as support of multiple browsing devices e.g. mobile devices.

The main advantages of the proposed approach can be summarized as follows:

- No special hypermedia and/or multimedia content should be designed and developed in order to enable access from specific target groups.
- Users can access available information resources independently from their abilities or disabilities.
- Access to the same information sources, eliminates the feeling of isolation.
- Communication and collaboration between people with diverse access needs can be addressed since the information in not dependent to access devices or abilities.

Figure 4 presents the proposed architectural approach for a web-based learning system supporting accessible hypermedia based on the principles described in the previous sections of the paper. This figure shows the structural components of the system and their interconnection paths. Interconnection between components is modelled by associations (directed arrows). These associations can represent direct connections or they can also be used to abstract away details of more complex connection and communication patterns (e.g. indirect communication based on events).

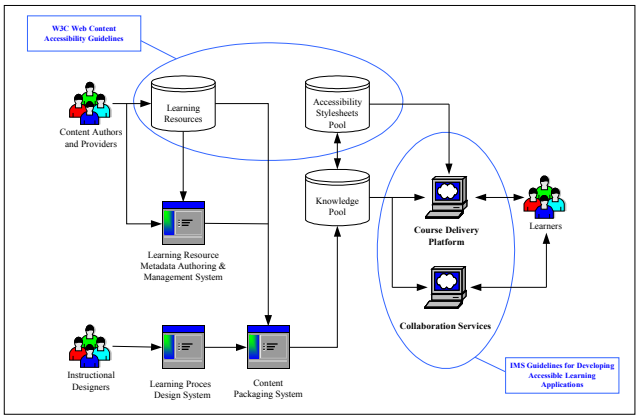

Figure 4: Accessible Web-based Learning System Architecture

The main components of this architecture are the following:

- *Learning Process Design System.* Existing Learning Technology Specifications are designed in order to ensure reusability of educational content within different authoring environments, content repositories and delivery platforms. The degree to which educational content can be reused in different contexts and re-purposed to serve different requirements depends on how it is stored, made available, and delivered. Common barriers to the reuse and adoption of learning materials include monolithic resources, tailored to specific requirements and able to address specific learning scenarios [28]. Instructional designers and content authors should be able to locate objects, change unsuitable components, combine them in a variety of different structures based on a diverse set of pedagogical approaches and exchange them among heterogeneous Content Management and Learning Management Systems. The only way that these goals can be achieved is to produce, package and deliver learning objects in a way that complies with emerging Learning Technology specifications, in

particular IMS Learning Design [29]. Learning Design specification is based on the established method for modeling learning activities – Educational Modeling Language (EML) [30], and supports multiple users acting multiple roles, working alone or collaboratively in groups. The Learning Process Design System should be based on the use of IMS Learning Design specification in order to provide to an instructional designer the environment for defining learning scenarios. The idea is to define generic, domain independent learning scenarios that can be used by the content packaging system in order to create learning activities based on the use of the existing hypermedia content. With this approach learning scenarios are separated from the content, thus allows the web-based learning system to deliver learning activities using user oriented learning scenarios based on hypermedia no specially designed for the target user group.

- *Content Packaging System*. A software tool that will enable organization of web-based learning content in reusable training courses that implement the training processes designed with the training process design system, compliant with the international learning technologies standards and specifications. The development of such packaging tool could be based on the commonly used IMS Content Packaging Specification [31] and the supported metadata for indexing the components of a training course could be based on the IEEE Learning Object Metadata Standard [32].
- *Learning Resources Metadata Authoring & Management System.* An environment that will support the metadata authoring and repository management. The main goal of this environment is to provide an easy-to-use and accessible from anywhere platform capable of authoring, storing, managing and deliver the educational metadata produced for supporting the accessible hypermedia content.
- *Course Delivery System and Collaboration Services.* A web-based course delivery platform and collaborative environment for virtual learning communities of users. This environment will provide the communication tools and collaboration environment for the users to participate in a learning community and have access to the hypermedia content available in the repository of learning resources.

The above mentioned components handle information stored in three repositories, namely:

- *Learning Resources Repository.* This repository stores the learning resources. A learning resource can be from a simple hypermedia or multimedia resource to complex hypermedia structure. Such a repository can be from a local repository to a network of distributed repositories.
- *Knowledge Pool Repository.* This pool stores the content packages defined by the use of the content packaging tool, representing desired learning activities designed with the learning process design system. Those content packages are also associated with the corresponding metadata for the resources included in the content packages.
- *Accessibility Style Sheets Pool*. This pool contains style sheets that need to be used in order to present the web-based courses to the users taking into account their accessibility preferences. These style sheets can be based on existing international accessibility specifications and recommendations, e.g. W3C Web Content Accessibility Guidelines and W3C Cascading Style Sheets recommendation [33].

So far, we presented an architectural definition of a web-based learning system that addresses all the design steps and requirements already identified based on the current state-of-the-art accessibility approaches and techniques. Open issue in the proposed architecture still remains the definition of an accessibility application profile for enabling the formalization of learning object accessibility properties, and the matching of learning content with learner accessibility preferences. Such an application profile needs to be used in order to link the accessibility style sheets with the learning content packages based on the learner accessibility preferences. The methodology that should be used for defining an accessibility application profile is presented in the next section of this paper. Furthermore, the next section provides an accessibility application profile of the IEEE LOM standard, produced as a result of the above mentioned process.

4.ACCESSIBILITY METADATAFOR LEARNING RESOURCES

4.1Methodology for defining an Accessibility Application Profile

As already presented, a key component for the design of an accessible web-based learning system is the definition of accessibility properties of learning resources, since those properties should be used for matching hypermedia content to:

- learner accessibility preferences
- browsing devices and/or interfaces
- presentation style sheets

Developing a set of standardized accessibility metadata will enable a variety of people, institutions, search engines, cataloguers etc, to describe learning resources using the same tag sets and therefore share and search learning object repositories for accessible resources [34, 35].

Although a generally accepted standard for the description of learning objects already exists, namely the IEEE Learning Object Metadata (LOM) standard, this metadata model lacks information on accessibility properties of learning objects. Thus, in order to identify the accessibility characteristics of learning objects, the integration of learning object metadata with accessibility metadata is needed. The output of this process is an accessibility application profile for learning objects.

Based on the three accessibility dimensions in web-based learning, we can identify information resources that can indicate possible extensions to the IEEE LOM standard concerning accessibility properties, namely Learner Specific Guidelines,

Content Specific Guidelines and Application Specific Guidelines. Figure 5 presents a schematic representation of the possible influence of the IEEE LOM model from those guidelines.

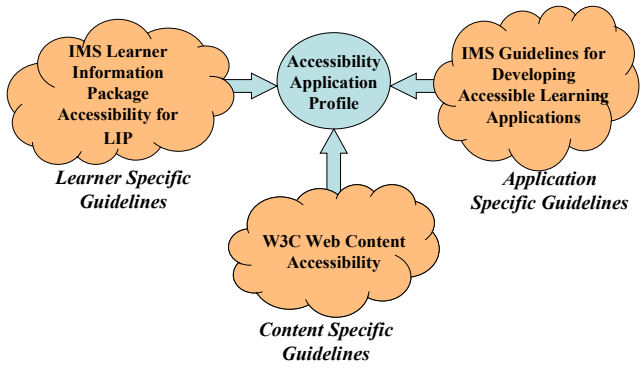

Figure 5: Specification and Guidelines that can indicate possible extensions to IEEE LOM standard concerning accessibility properties of learning resources

The process of deriving accessibility metadata from the identified guideline categories consists of the following key steps:

- *Step1: Identifying the related IEEE LOM element.* During this step an analysis of a specific checkpoint is conducted in order to identify the most related IEEE LOM element with the specific checkpoint. The identification of the related element is based on the semantics of the element as well as the semantics of the required metadata in order to reach the checkpoint.
- *Step2: Extending Value Space.* This step includes the identification of possible extensions required in the value space of the related IEEE LOM in order to reach the checkpoint. This process extends when necessary the value space or vocabulary that the related element uses.
- *Step3: Adding new sub-elements to the related LOM element.* During this step new elements are added if necessary to the information model, with special attention for avoiding semantic overlaps with other existing elements of the information model.

In this paper we address the design of an IEEE LOM accessibility application profile based on learner specific guidelines and more precisely the IMS AccLIP specification. The resulted application profile is presented in the next section. Figure 6 presents a generalized view of the IEEE LOM categories that we identified to be related with accessibility properties of learning resources during the design of the IEEE LOM accessibility application profile.

4.2IEEE LOM Accessibility Application Profile

In this section, we present an accessibility application profile of the IEEE LOM based on IMS Accessibility for LIP recommendations. The introduced extensions to the IEEE LOM information model are presented in a tabular form for each identified IEEE LOM category presented in Figure 6. More specifically:

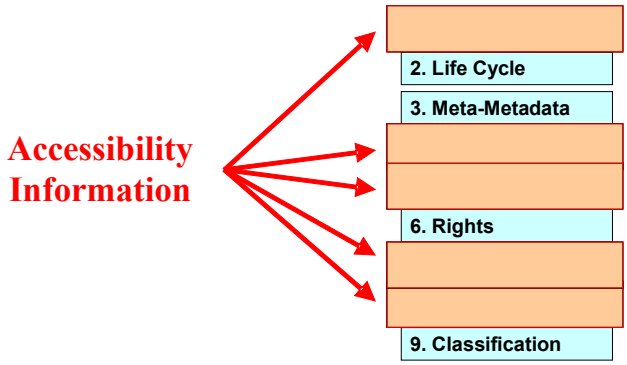

Figure 6: Addressing Accessibility Information in the IEEE LOM information Model.

4.2.1 Extension of IEEE LOM General/Language Element

The IEEE LOM General/Description element describes the human languages used within a learning object to communicate to the intended user. Since sign languages can also be a case in the communication with the indented user, an extension of this element is needed. Table 1 presents the introduced extension to the IEEE LOM General/Description element based on description of alternatives to visual or auditory learning objects.

Requirements from ACCLIP model		
AccLIP Elements	**Definition**	**Meta-Data Required**
1.1 alternativesToVisual 1.1.1 audioDescription	Audio descriptions of visual elements	Meta-data on audio description that includes pointer to primary video and a label of either "expanded" or "standard"
1.1.1.1 xml:lang	Language to use for audio descriptions	Meta-data specifying the language of the audio description
1.1.2 altTextLang	Language to use for alt text	Meta-data on alt-text identifying language of alt-text
1.1.3 longDescriptionLang	Language to use for long descriptions	Meta-data identifying language of long-desc.
1.3 alternativesToAuditory 1.3.1 captionType	What form of text caption is preferred.	(container)
1.3.1.2 verbatim	Enable verbatim captions which may include descriptions of sound effects. Mutually exclusive with *reducedReadingLevel*	Meta-data on caption that includes pointer to primary video, synchronization file if necessary and a label verbatim.
1.3.1.3 reducedReadingLevel	Reduce the reading level. Mutually exclusive with verbatim.	Meta-data on caption that includes pointer to primary video, synchronization file if necessary and a label of reduced reading level.
1.3.1.5 enhancedCaption	Enhance the captions to include more information. This includes the use of video layers to provide information about the paralinguistic content of speech, music, and other non-speech sounds.	Meta-data on caption that includes pointer to primary video, synchronization file if necessary and a label of enhanced

Extension of IEEE LOM	
1.4 Description	
Proposed # and Name	**1.4.1 DescriptionType**
Definition	The type of the description
Occurrence	Single Instance
Order	Unspecified
Proposed # and Name	**1.4.1.1 Verbatim**
Definition	Verbatim descriptions which may include descriptions of sound effects. Mutually exclusive with reducedReadingLevel
Occurrence	Single Instance
Order	Unspecified
DataType	LangString (smallest permitted maximum: 1000 char)
Proposed # and Name	**1.4.1.2 reducedReadingLevel**
Definition	Reduce the reading level. Mutually exclusive with verbatim
Occurrence	Single Instance
Order	Unspecified
DataType	LangString (smallest permitted maximum: 1000 char)
Proposed # and Name	**1.4.1.3 enhanced**
Definition	Enhance the captions to include more information.
Occurrence	Single Instance
Order	Unspecified
DataType	LangString (smallest permitted maximum: 1000 char)

Table 1: Extension of IEEE LOM General/Description Element

4.2.2 Extension of IEEE LOM General/ Description Element

The IEEE LOM General/Description element provides a textual description of the content of a specific learning object. The language and the terms that are to be used in this element are intended for those who make decisions whether a specific learning object is appropriate and relevant for those that will use it. Thus, analytic textual descriptions even in the case of multimedia-based learning objects are needed in order to enable access through screen readers or other text-to-speech engines.

4.2.3 Extension of IEEE LOM Technical Category

The IEEE LOM Technical category describes the technology (hardware, network, software) that is required for using a learning object. It also provides characteristics, such as the size or the location of a learning object. In the case of multimedia-based learning objects (image, video etc.) specific technical properties concerning the use of colors in learning objects should be specified, otherwise people with color blindness could not access the learning objects.

4.2.4 Extension of IEEE LOM Educational Category

The IEEE LOM Educational category describes the educational or pedagogical characteristics of a learning object. These characteristics include the interactivity type, the semantic density and the level of difficulty of a learning object, the time that a typical user takes to work with it, etc. Extension to this category is needed in order to include links with tools that allow the learner to concentrate on the focus of the learning activity.

4.2.5 Extension of IEEE LOM Relation Category

The IEEE LOM Relation category defines the relationships between learning objects. In order to locate and retrieve an alternative learning object, relationships with the primary learning object should be defined. This process requires the extension of the IEEE LOM Relation category to include the link to and from visual, text or auditory alternatives of the primary learning object.

4.2.6 Use of IEEE LOM Annotation Category

Finally, Table 1 presents the use of the IEEE LOM Annotation category in order to include annotations on the use of a learning object.

Requirements from ACCLIP model		
AccLIP Elements	**Definition**	**Meta-Data Required**
1.7 structuralPresentation 1.7.5 showNotes	Display annotations (notes) when available.	Meta-data on annotations with pointer to primary content annotated and synchronization or link file.

Extension of IEEE LOM			
ACCLIP Element		**IEEE LOM Element**	
Element # and Name	**1.7.5 showNotes**	**Standard # and Name**	**8 Annotation**
Definition	Display annotations (notes) when available	Definition	Provides comments on the educational use of the learning object and information on when and by whom the comments were created
		Occurrence	Smallest permitted maximum: 30 items
		Order	Unordered

Table 1: Use of IEEE LOM Annotation Category

The presented IEEE LOM accessibility application profile has been developed in the context of CEN/ISSS Learning Technologies Workshop as an initial proposal produced by our research group for consideration in the project team entitled "Accessibility properties for Learning Resources" [36].

5.CONCLUSION

In this paper we presented the accessibility dimensions in web-based learning, trying to identify the main design requirements for designing an accessible web-based learning system. For each accessibility dimension we analyzed the accessibility requirements, presented the state-of-the-art and discussed the open issues concerning web-based learning systems design.

We presented an architectural definition of a web-based learning system that addresses all the design steps and requirements identified based on the current state-of-the-art accessibility approaches and techniques. The proposed architecture is based on three design principles, namely:

- Separation of hypermedia content from the delivery platform
- Separation of content information from presentation information
- Separation of hypermedia content from learning scenarios

This approach has several benefits, including:

- Support of hypermedia designed based on requirements for different target user groups, thus the proposed architecture approach is generic enough to enable a web-based learning system to act as a rendering device affected by pedagogy independent from the learning content to be delivered.
- Provides the flexibility to support individualized presentation styles based on learner accessibility preferences, as well as support of multiple browsing devices e.g. mobile devices.
- Limits the need for design and development of special hypermedia and/or multimedia content in order to enable access from specific target groups.
- Offers access to the same information sources, eliminating the feeling of isolation for people with disabilities.
- Provides the means for communication and collaboration between people with diverse access needs since the information in not dependent to access devices or abilities.

Moreover, we discussed the need to define an accessibility application profile for enabling the formalization of learning object accessibility properties, and the matching of learning content with learner accessibility preferences. As a result, we presented a methodology for defining such an application profile based on the three accessibility dimensions and presented the first step towards the definition of the application profile. The proposed IEEE LOM accessibility application profile has been developed in the context of CEN/ISSS Learning Technologies Workshop as an initial proposal produced by our research group for consideration in the project team entitled "Accessibility properties for Learning Resources"

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