Profiling Learners with Special Needs for Custom E-Learning Experiences, a Closed Case?

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ABSTRACT

Contrary to what commonly thought, profiling users and devices is still a complex issue, especially in the case of learners with special needs, who deserve a customized access to e-learning platforms. A plethora of languages, protocols and tools have been proposed which can be exploited to create users' and devices' profiles, separately. Unfortunately, none of them is really effective in capturing the fundamentals of a learner profile, when used in isolation. Here we discuss a practical approach we devised to profile e-learners, which is able to meet the variety of requirements providing educational experiences. Our approach is based on the idea to put together the strengths of ACCLIP and CC/PP protocols, while avoiding specification conflicts. A few examples are provided which show the efficacy of the approach.

Categories and Subject Descriptors

K.3.1 [**Computers ad Education**]: Computer Uses in Education, Distance learning; K.4.2 [**Computers and Society**]: Social Issues, Assistive technologies for persons with disabilities.

General Terms

Design, Experimentation, Human Factors, Standardization.

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Keywords

E-learning accessibility, Profiling, Device capabilities, Learners preferences.

1. INTRODUCTION AND PROBLEM STATEMENT

A myriad of new devices has changed the way to access the Internet and is now affecting also the e-learning world. The use of wireless technologies and pervasive computing may really enhance the educational learners' experience by offering mobile e-learning services which can be accessed through handheld devices. This new paradigm of educational content distribution maximizes the benefits for learners, since it enables to overcome constraints imposed by the surrounding environment.

Some ways to classify different terminals in hand of users have been determined [12]. All the technical characteristics of each single device can be easily mapped by exploiting some language or specific description protocol. The opportunity of profiling client terminals opens up new e-learning scenarios, according to which specific contents can be delivered to the user on the basis of his device. Just as an example, textual-based information can be delivered to users accessing content via a cell-phone, while rich media contents may be provided to users who use a fully equipped PC.

On the other hand, the growth and the effectiveness of current assistive technologies now pushes disabled users to increasingly access the Web and exploit its related services. This important trend gains even more significance in e-learning contexts. Indeed, while in the beginning of the e-learning age, most educational institutions paid little attention to making their system accessible to disabled users, non-conventional students, now making learning contents accessible to all the learners has become a major concern for most e-learning content providers. As a matter of facts, accessible e-learning would allow distance and flexible educational activities, thus decreasing the risk of excluding individuals with particular access capabilities and increasing the social inclusion of non-typical learners [10, 11].

As to these accessibility issues, it is worth mentioning that users can be fully profiled by resorting to some kind of languages or protocols, which enable to describe their physical characteristics and/or limitations [4, 5, 6].

However, it turns out that providing didactical materials to learners who may access contents through the use of different devices and may have very diverse personal needs (or physical constraints) is a hard task. Indeed, none of the proposals for profiling users is able to capture all the characteristics of any learner together with and his device. Instead, such a kind of complete information could be profitably exploited so as to increase the didactical experience provided to students. Based on such information, in fact, flexible strategies can de devised, which are able to produce accessible, customized and multimedia learning experiences to learners with different skills and which gain access through the use of diverse devices.

With this aim in view, we have devised a practical approach to profile e-learners, which is able to meet the variety of requirements providing customized educational experiences. Basically, our approach is based on the idea to put together the strengths of ACCLIP [5], i.e., a standard specification used to profile users in terms of accessibility constraints, and CC/PP [12], i.e., the well known protocol thought to profile technical characteristics of devices in terms of hardware and software capabilities.

This way, according to our profiling scheme, those requirements which are needed by the user to access a given content are described using ACCLIP derived elements, while software/hardware features' availability on the device in use is described using CC/PP derived elements. Based on this approach, user needs may be easily put in correspondence with system characteristics, which need to be used in a specific context. When user requirements (described in the profile with ACCLIP derived elements) have corresponding system features (described in the profile with CC/PP derived elements) available on the terminal, contents may be fully enjoyed by users according to specified, required formats.

Our profiling approach has been included in a Web-based e-learning platform we developed. Basically, our system is able to dynamically adapt rich media didactical contents, based on the exploited profiling approach, in order to meet learner needs and device capabilities [9].

In this paper, few examples are provided which show the efficacy of the described approach.

The remainder of the paper is structured as follows. Section 2 provides a background on well-known methods to profile learners and devices, and discusses their advantages and limitations. Section 3 describes our profiling approach, based on user preferences and needs as well as device characteristics. Section 4 sketches the system we developed, able to adapt LOs by means of a component that employs our approach to manage learners' profile. Section 5 illustrates some use cases to demonstrate the viability of the adopted solution. Finally, Section 6 concludes the paper.

2. PROFILING LEARNERS AND DEVICES: A BACKGROUND

2.1 Profiling Learners

The IMS Global Learning Consortium [5] has developed the IMS Learner Information Package (IMS LIP) specification [6], with the aim of addressing interoperability issues among Internet-based learner information systems. The intent of the specification is to define a set of packages that can be used to import (extract) data into (from) an IMS compliant e-learning platform.

IMS LIP is based on a data model, which describes learner characteristics which are necessary for learning purposes. Such a specification supports the exchange of learner information among learning management systems, human resource systems, student information systems, enterprise e-learning systems, knowledge management systems, resume repositories and other system used in any learning process.

The IMS LIP core structures are based upon several and different subjects; the most important ones are listed in the following:

- *Identification information* defines biographic and demographic data which are relevant to e-learning.
- *Goal information* describes learning, career and other objectives and aspirations.
- *Qualifications, certifications and licenses information* specifies such characteristics as long as they are granted by recognized authorities.
- *Activity information* describes any learning-related activity in any state of completion. Such information could involve formal and informal education, training, work experience, and military or civic service.
- *Competency information* specifies acquired skills, knowledge and abilities in the cognitive, affective and or psychomotor domains.
- *Relationship information* describes the relationships among the different core components.

The IMS Accessibility Learner Profile (IMS ACCLIP) [5], which is a part of IMS LIP [6], is devoted to describing students' accessibility constraints [2].

ACCLIP describes the user in terms of accessibility needs by using a XML-based syntax. Basically, it enables the description of user preferences (visual, aural or device), which can be usefully exploited for tailoring learning contents (e.g., preferred/required input/output devices or preferred content alternatives). In other words, such a personal user profile provides a means to describe how learners interact with an e-learning environment, by focusing on accessibility requirements. While certainly useful for describing and managing accessibility issues, a limitation of this specification is that it does not consider the characteristics of the devices exploited by learners. As we will show in the next Section, we have utilized ACCLIP in our profiling approach to characterize personal characteristics of learners. Thus, since this specification is central in our system, we now focus on some important details of it.

The accessibility preferences defined in the ACCLIP can be grouped into four sections, as reported in the following (XML tags representing these information are also reported):

- *Display information* (`<display>`); this data describes how information should be displayed or presented to the user. For example, it is possible to define preferences related to cursor, fonts and colors characteristics (`<cursorSize>`, `<cursorColor>`, `<foregroundColor>`, `<backgroundColor>`, `<fontSize>`, `<fontFace>`). In addition, it is possible to declare the necessity of using a screen reader (`<screenReader>`), by specifying the interaction preferences, such as the speech rate, the pitch and the volume (`<speechRate>`, `<pitch>` and `<volume>`), or the need of visual alerts instead of aural ones (`<visualAlert>`).
- *Control information* (`<control>`); this data defines how a user prefers to control the device. For example, it is possible to define preferences related to the standard keyboard usage (`<keyboardEnhanced>`). In addition, it is possible to declare the need of using non typical control mechanism, such as onscreen keyboard (`<onscreenKeyboard>`), alternative keyboard (`<alternativeKeyboard>`), mouse emulation (`<mouseEmulation>`), alternative pointing mechanism (`<alternativePointing>`) and voice recognition (`<voiceRecognition>`).
- *Content information* (`<content>`); this data describes which enhanced, alternative or equivalent contents are required by the learner. For example, it is possible to define how to present visual, textual and auditory contents in different modalities (`<alternativesToVisual>`, `<alternativesToAuditory>`, `<alternativesToText>`) and the necessity of personal style sheets (`<personalStylesheet>`).
- *Eligibility information* (`<accomodation>`); this data allows the recording of requests for and authorization of accessibility accommodations for testing or assessment. For example, it is possible to declare the request for accommodations and the accommodation description (`<requestForAccomodations>`, `<accomodationDescription>`).

An ACCLIP profile describing a learner can be used to configure a computer workstation with appropriate assistive technologies, or reconfigure a Web application for a person with a learning disability or a cognitive impairment [5].

The IMS Global Learning Consortium specifies also standards devoted to provide content metadata and to define content alternatives, in order to improve didactical materials accessibility. The IMS AccessForAll Meta-Data (ACCMD) specification [4] describes adaptable learning contents by specifying which typologies of (primary and alternative) media resources are available in a LO, which can be used to present the content to any given user. For example, metadata can be utilized to state that text alternatives are available for images, descriptive audio for video content, transcripts or captioning for audio tracks, visual alternatives for text, colour alternatives to increase contrast, reduced alternatives for small screens and a variety of other potential alternative formats. Thus, ACCMD makes possible to identify any resources which match user's stated preferences or needs. The idea is that if the ACCMD specification is implemented in an e-learning platform, smart strategies can be devised to select (alternative) media resources, composing a LO, which can be fully enjoyed by a given user. In other words, ACCLIP profiles can be utilized to determine which typologies of media should be provided according to their user characteristics and needs. Based on ACCMD, these appropriate alternative media resources can be retrieved and presented to him. ACCMD is the mirror of ACCLIP, providing an interpreter for ACCLIP profiles and allowing to choose the appropriate content, based on the previous interpretation. By entering an ACCLIP profile, a blind user trying to access a video for example, will automatically receive that video with descriptive audio. A deaf user will receive the same video but with captioning included in the presentation.

Some projects have been done in the direction of managing Learning Objects (LOs), based on the idea of adapting contents and their presentation in a suitable way. Yet, none of these ones took into account device capabilities (while our system does it). As a consequence, their LO adaptation can not be effectively completed so as to completely meet more general users requirements. In particular, The Inclusive Learning Exchange (TILE) [7, 13] is a learning object repository, developed by the Adaptive Technology Resource Centre at the University of Toronto, which implements both ACCMD [4] and ACCLIP [5]. Whenever authors use the TILE authoring tool to aggregate and publish learning objects, they are supported in creating and appropriately labelling transformable aggregated lessons (codified by the TILE system using ACCMD). Learners are enabled to define their learner preferences, which are then stored as IMS ACCLIP records. Thanks to such information, TILE inspects any learner's state preferences and computes the best resource configuration by transforming or re-aggregating lessons.

The Web-4-All project [7] [14] is a collaboration project between the Adaptive Technology Resource Centre, the Canadian Web Accessibility Office of Industry and the IMS Global Learning Consortium. This project allows learners to automatically configure a public access computer by using a learner preferences profile, implemented with the ACCLIP and stored on a smartcard. Thanks to information within his smartcard, each learner can freely switch from one public workstation to another. When the smartcard is read by the workstation, the Web4All software automatically configures the operating system, the browser and all the necessary assistive technologies, based on the learner profile. If the assistive technology requested by the learner is not available on a workstation, the program launches and configures the closest to it.

2.2 Profiling Devices

Different standardized methods are devoted to profile devices. The most prominent ones available in literature are mainly based on RDF (Resource Description Framenwork) profiles, such as the Composite Capabilities/Preference Profile (CC/PP) [15] and User Agent Profile (UAProf) [8]. These are two related standards, recommended by the W3C and by the Open Mobile Alliance (OMA). As the diversity of devices increases, device capabilities and preferences for profiling devices must be known. The goal of these profiles is to allow client devices to inform servers of their capabilities.

The CC/PP and UAProf data formats exploit two-level hierarchies consisting of components and attributes. Whenever we parse these profiles, RDF is an abstraction level over XML, so it must validate both XML and RDF. CC/PP and UAProf are also useful for device independence, content negotiation and adaptation, as they allow different devices to specify their capabilities in a uniform way.

CC/PP provides a standard way for devices to transmit their profiles when requesting Web content. Servers and proxies can then provide an adapted content, which is appropriate to the connected device [15]. A CC/PP vocabulary is defined by using RDF and specifies components and their attributes to be used by the application so as to describe a certain context. The three main components specify a hardware platform, a software platform and a browser user agent. In particular:

- *Hardware Platform*: this component defines the device (mobile device, personal computer, palmtop, tablet PC, etc…) in terms of hardware capabilities, such as `displaywidth` and `displayheight` (which specify display width and display height resolution), `audio` (which specifies audio board presence), `imagecapable` (which specifies images support), `brailledisplay` (which specifies Braille display presence), `keyboard` (which specifies keyboard type).
- *Software Platform*: this component specifies the device software capabilities, such as `name` (which specifies operating system name), `version` (which specifies operating system version), `tool` (which specifies present assistive tools), `audio` (which specifies supported audio types), `video` (specifies supported video types), `SMILplayer` (which specifies present SMIL players).
- *Browser User Agent*: this component describes the browser user agent capabilities, such as `name` (which specifies user agent name), `version` (which specifies user agent version), `javascriptversion` (which specifies javascript versions supported), `CSS` (which specifies CSS versions supported), `htmlsupported` (which specifies HTML versions supported), `mimesupported` (which specifies mime types supported), `language` (which specifies languages supported).

There are two key problems related to device independence, which are beyond CC/PP working group scope:

1. CC/PP profile does not provide a standard vocabulary for Web clients to communicate their capabilities to servers.
2. CC/PP profile does not describe the type of adaptation methods that servers should perform on behalf of devices according to their capabilities.

UAProf is defined as a standard between WAP devices and servers. Such a profile can be used for better content adaptation on different types of WAP devices [8]. The advantage of UAProf is the definition of different categories of mobile device capability. The weakness of this standard is that it does not resolve how servers and proxies should use the UAProf profile. In addition, it is exclusively devoted to profile mobile devices.

Some projects have involved CC/PP and UAProf standards in order to profile devices. The Sun Microsystems Inc. has defined a specification, which details a set of APIs for processing CC/PP information, in order to enable interoperability between Web servers and access mechanism, facilitating device independent Web applications development [12]. DELI [1] is an open-source library developed at HP Labs, which provides an API allowing Java servlets to determine the delivery context of a client device using CC/PP or UAProf. Java servlets resolve HTTP requests containing delivery context information from CC/PP or UAProf capable devices and query the resolved profile, replacing proprietary delivery context descriptions with standardized CC/PP descriptions, if it is necessary.

3. PROFILING LEARNERS FOR CUSTOM E-LEARNING: A PRACTICAL APPROACH

In this Section, we describe our profiling scheme. The basic idea behind our approach is that each profile must describe both the device in use and learner's characteristics, which are needed to identify accessibility issues.

We mentioned that several standards and solutions have been proposed without generating an exhaustive and fully supported solution. In fact, while CC/PP offers an open profiling mechanism, it defines a common vocabulary that fully describes only the device [12]. On the other side, ACCLIP outlines the user in terms of accessibility needs, without considering device characteristics [5]. In order to completely profile learners and devices, we need to consider both the user needs and her/his device capabilities. Hence we couple these two standards. Specifically, the IMS ACCLIP specification is exploited to profile

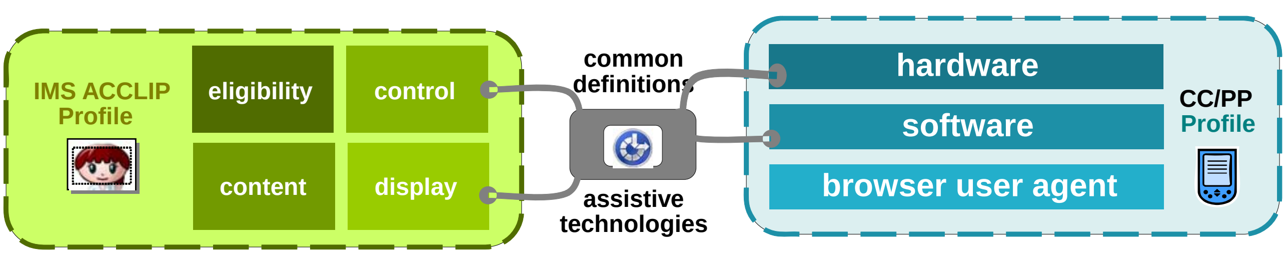

Figure 1 – ACCLIP and CC/PP Specifications: Common Definitions

learners. W3C's CC/PP standard, instead, is used to profile devices.

A comparative analysis of ACCLIP and CC/PP shows that the whole set of characteristics they cover, when put together, perfectly matches with those needed to exhaustively profile learner's context. The union of such two sets of descriptions represents a complete profile of the dyad (learner, device).

ACCLIP Profile U CC/PP Profile = Complete Profile

Not only, in their specifications ACCLIP and CC/PP share some technical characteristics of clients. In particular, all the information related to the assistive technologies that are declared in CC/PP as hardware and software components are reported also in ACCLIP as accessibility tools, which may be (possibly) used by (non conventional) learners.

Figure 1 shows the ACCLIP and CC/PP profiles intersection. However, even if these two specifications take into consideration common elements in their profiles, the latter ones play different roles in our profiling approach whenever they are used in isolation. Indeed, ACCLIP derived elements fully describe the user and his needs, thus identifying the requirements to fully support the learner.

On the other hand, the CC/PP profile describes the characteristics of the device in use, thus determining specific software/hardware features' availability. In other words, in certain cases the presence of a requirement in the ACCLIP profile (e.g., the request for the use of a screen reader) corresponds to the necessity of having a given software/hardware feature available on the terminal (e.g., the device is equipped with a screen reader). As a matter of fact, cases exist when, instead, the availability of a given software/hardware tool (properly included in the CC/PP derived elements) does not correspond to a user requirement (i.e., the request for the use of that tool is not included in the ACCLIP derived elements). For example, an assistive technology (e.g., screen reader) can be installed on a device in use by people without disabilities (e.g., people who test accessibility application, people who share a device with someone else with a disability).

Based on these considerations, our mechanism for profiling learners, works as follows. Both ACCLIP and CC/PP specifications are utilized to fully describe users' needs and devices' capabilities. For any personal features which correspond to some specific software/hardware characteristics required for the device in use, the following cases may arise, which are properly managed by our profiling scheme:

1. Some specific requirement, detailed in the ACCLIP derived elements, corresponds to a feature availability on the exploited device, detailed in related CC/PP derived elements (e.g., a request for the use of a screen reader, which is properly installed on the device). In this positive case, the feature is exploited so as to meet the user's needs.

2. Some specific requirement, detailed in ACCLIP derived elements, does not corresponds to a feature availability on the device, detailed in CC/PP derived elements (e.g., a request for the use of a screen reader, not available on the device). In this negative case, the feature cannot be exploited and, if possible, alternative solutions are needed.

Some specific system features are present based on CC/PP, which are not requested in the ACCLIP (e.g., presence of a screen reader, not requested by the user). In this case, such features are not considered by the system.

4. THE SYSTEM AT A GLANCE

The presented profiling approach has been included in a content adaptation service oriented system, thought to be exploited in Web-based educational contexts. Basically, our system is able to dynamically adapt rich media didactical contents, based on the exploited profiling approach, in order to meet learners' needs and device capabilities [9]. A sketch of the whole system architecture is depicted in Figure 2.

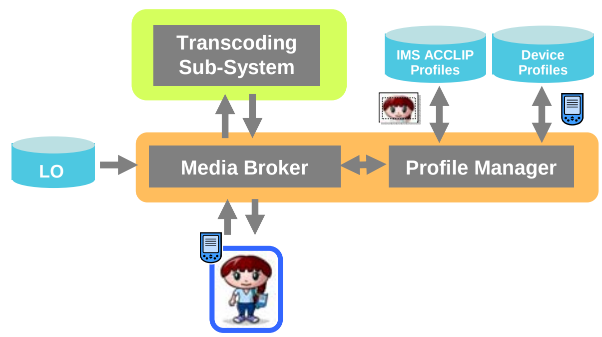

Figure 2 - The whole system architecture

We can summarize our system activities as follows:

- *Broking activity*: the system behaves as a broker, which manages each specific user request to provide her/him with an adapted, suitable version of a LO, based on her/his specific profile.
- *Transcoding activity*: the system orchestrates a set of specific transcoding Web Services employed to transform and adapt the requested LO.
- *Profiles managing activity*: a system component, called *Profile Manager*, is devoted to manage our user profiles.

Basically, as soon as the learner issues a request for a particular didactical content, the client application contacts the system by authenticating himself/herself to the broking component (called *Media Broker*). During the first connection to the system, the learner specifies his profile, structured as previously detailed. Such profile is mapped into a unique ID. All such information is passed to the Profile Manager, which controls a Profile DB. (Then, during every following access to the system, the user is simply asked to specify only such a unique ID.) Thus, as soon as a request arrives to the Media Broker, it interrogates the Profile Manager and retrieves the user's profile. Based on such a profile, the system schedules and orchestrates a content adaptation strategy for rich media contents composing a LO. In particular, our system invokes and executes, for each media composing the LO, the most appropriate transcoding process, so as to produce a customized LO that can be fully enjoyed by each (impaired or mobile) student.

When producing a new profile, in order to reduce the number of attributes which need to be introduced, we have integrated a profile Data Base, containing user preferences, with a set of device capability descriptions derived from *WURFL* (Wireless Universal Resource File Library DB) [17]. WURFL is a free and open source project that provides information about device capabilities and currently describes about 7.000 different devices, identifying about 300 characteristics. WURFL represents the most complete and updated XML-based, open mobile devices description repository. We set a number of pre-configured standard profiles to further simplify the definition of user preferences and device capabilities. Users can decide whether to maintain a pre-set profile or to modify it by creating a new, personal and customized one, that is identified by a unique user ID. Once the Media Broker gets learner's and device profiles, it passes them as input information to the component devoted to transcoding operations.

5. PROFILERS AT WORK: A FEW EXAMPLES

In order to prove the effectiveness of our profiling approach, we tested our system with dozens of different user profiles. In this paper, we report on three significant ones. Such scenarios illustrate three learners requesting a SCORM package LO [2] with a SMIL [16] video lecture, by using different hardware and software platforms.

The original LO was composed by the following media contents:

i) a video content showing the lecturer,
ii) an audio content embodying the lecturer's talk,
iii) a sequence of static images, representing the lecture slides.

Moreover, two other information flows were added and maintained synchronized with the other ones:

iv) a caption sequence used to store the lecturer's speech in a textual format, and finally,
v) an additional textual description of contents, which are associated to each slide.

The two last additional content types were added to the LO in order to ensure portability and accessibility of the encoded contents. When needed, in the following we will describe IMS ACCLIP and CC/PP profiles. For the sake of readability and to enforce compliance to existing standards, we will maintain the original XML-based format for ACCLIP and RDF-based format for CC/PP.

5.1 A Mobile Learner (Scenario A)

As a first use case, let consider a scenario according to which a non disabled learner (say *A*) is accessing a LO through the use of normal PC. His PC is equipped with a screen reader, which is a feature commonly available in most operating systems. This information is thus reported in the CC/PP derived elements of the user profile. However, since the user is not blind, the need for the use of such an assistive technology is not reported (in the ACCLIP derived profile elements). Thus, based on this profile, our system correctly ignores the presence of the screen reader on the PC.

5.2 A Mobile Deaf Learner (Scenario B)

Let consider in much deep details the case of a deaf user (say *B*) which gains access to the lecture by means of a PDA. His handheld device has a small screen, reduced computational capabilities and it does not support the SMIL technology.

Figure 3 depicts the part of *B*'s profile which relates to ACCLIP specification. Basically, a set of preferences are specified about different input control systems, due to the use of a PDA. In particular, mouse emulation is allowed (see element `<mouseEmulation>` inside `<control>` element).

In addition, the user defines a set of preferences about visual alerts instead of generic audio ones (see element `<visualAlert>` inside `<display>` element). It is worth noticing that IMS ACCLIP defines a set of means to describe just device control, but no information about supported formats and display dimensions are provided. Indeed, these device-related characteristics are fully described thanks to the CC/PP derived elements.

```
...
<accessForAll schemaVersion="1.0.29"
xmlns="http://www.imsglobal.org/xsd/acclip"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-
instance" xsi:schemaLocation="
http://www.imsglobal.org/xsd/AccessForAllv1p0.xsd
">
<context identifier="userA" xml:lang="it">
  <display>
     <visualAlert>
        <visualAlertGeneric>
           <systemSounds value="captionBar"/>
           <captions value="true"/>
        </visualAlertGeneric>
     </visualAlert>
  </display>
  ...
  <control>
     <mouseEmulation>
        <mouseEmulationGeneric>
        <speed value="0.5"/>
          <acceleration value="0.5"/>
          <device value="keypad"/>
        </mouseEmulationGeneric>
     </mouseEmulation>
  </control>
</context>
</accessForAll>
...
```

Figure 3 - IMS ACCLIP in Scenario B

Figures 4, 5 and 6 show the code fragments of the three main CC/PP components, which define mobile device platform characteristics.

A consideration worth of mention is that, as reported in Figure 6, a screen reader (i.e., Jaws) is available on the client device. Of course, this client system feature is useless (and its use would be definitively not correct) in this specific scenario, since the user is deaf. This fact is supported by the ACCLIP derived elements, according to which no need for such an assistive technology is required. As expected, our system correctly exploits this information and does not consider the presence of a screen reader on the terminal, as a request for an audio-based presentation of contents. Instead, only visual presentations of contents are exploited.

```
[sfa:AProfile]
 |
 +ccpp:component->
           [sfa:TerminalHardware]
 |          |
 |          +-rdf:type->sfa:HardwarePlatform]
 |          +--ex:displayWidth----> "240"
 |          +--ex:displayHeight---> "320"
 |          +--sfa:audio----------> "yes"
 |          +--sfa:imagecapable---> "yes"
 |          +--sfa:brailledisplay-> "no"
 |          +--sfa:keyboard-------> "no"
...
```

Figure 4 - CC/PP Hardware Platform Component Profile in Scenario B

```
...
 +ccpp:component->
         [sfa:TerminalSoftware]
 |        |
 |        +-rdf:type-> [sfa:SoftwarePlatform]
 |        +-ccpp:defaults-> [sfa:SWDefaults]
 |        +-sfa:name------> "Pocket PC"
...
 |        +-sfa:tool-------->[ ]
 |        |                   |
 |        |  ----------------
 |        |  |
 |        |  +--rdf:type---->[rdf:Seq]
 |        |  +--rdf:_1------>"jaws6.20"
...
 |        +-sfa:audio----------> [ ]
 |        |                       |
 |        |  --------------------
 |        |  |
 |        |  +--rdf:type---> [rdf:Bag]
 |        |  +--rdf:_1-----> "wav"
 |        |  +--rdf:_2-----> "mp3"
 |        |  +--rdf:_3-----> "mid"
 |        |
...
```

Figure 5 - CC/PP Software Platform Component Profile in Scenario B

5.3 A Fully Equipped Blind Learner (Scenario C)

Let now be *C* a blind user who gains access to the Internet with a PC equipped with a screen reader and a Braille display (i.e., the assistive technologies that enable blind people to use a computer). A SMIL player is installed on the system.

A simplified portion of ACCLIP derived elements comprised in *C*'s profile is reported in Figure 7. Here, a set of preferences is specified, related to the use of the screen reader (see element `<screenReader>` inside `<display>` element), as well as the Braille display characteristics (see `<braille>` element, partially omitted). All these elements are included inside the accessibility LIP element (`<AccessForAll>`) which drives the system transcoding process. Based on this profile, the system produces an alternative version of each graphical and visual content.

```
...
|
+-ccpp:component->
     [sfa:TerminalBrowser]
      |
      +-rdf:type------> [sfa:BrowserUA]
      +-ccpp:defaults-> [sfa:UADefaults]
      +-sfa:name-->"Pocket Internet Explorer"
      +-sfa:version---> "4.1"
      +-sfa:javascriptversion-> [ ]
      |                          |
      |  -----------------------
      |  |
      |  +--rdf:type---> [rdf:Bag]
      |  +--rdf:_1-----> "1.5"
      |
      +--sfa:CSS-------------> [ ]
      |                         |
      |  ----------------------
      |  |
      |  +--rdf:type---> [rdf:Bag]
      |  +--rdf:_1-----> "1.0"
      |
      +--sfa:htmlsupported---> [ ]
      |                         |
      |  ----------------------
      |  |
      |  +--rdf:type---> [rdf:Bag]
      |  +--rdf:_1-----> "3.2"
      |  +--rdf:_2-----> "4.01"
      |
      +--sfa:mimesupported---> [ ]
      |                         |
      |  ----------------------
      |  |
      |  +--rdf:type---> [rdf:Bag]
      |  +--rdf:_1-----> "text/html"
      |  +--rdf:_2-----> "text/plain"
      |  +--rdf:_2-----> "audio/mpeg"
      |  +--rdf:_2-----> "text/css"
     ...
      |
      +--sfa:language--------> [ ]
                                |
         ----------------------
         |
         +--rdf:type---> [rdf:Seq]
         +--rdf:_1-----> "it"
```

Figure 6 - CC/PP Browser User Agent Component Profile in Scenario B

Figures 8, 9 and 10 show the Hardware Platform, the Software Platform and the Browser User Agent CC/PP derived elements of the user profile. In this specific scenario, hardware and software assistive technologies (Braille display and Jaws, the screen reader) are provided. Based on the user requirements (reported in the ACCLIP derived elements) and on the availability of the needed software/hardware tools (reported in the CC/PP derived elements), our system is able to set the use of these features during the presentation of contents, so as to perfectly meet user requirements. In order to properly use these technologies, alternative textual description for contents which were originally encoded as visual ones (e.g., images, videos) are exploited during the presentation.

```
...
<accessForAll schemaVersion="1.0.29"
xmlns="http://www.imsglobal.org/xsd/acclip"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-
instance" xsi:schemaLocation=
"http://www.imsglobal.org/xsd/AccessForAllv1p0.
xsd">
<context identifier="userB" xml:lang="it">
          <display>
     <screenReader>
        <screenReaderGeneric>
          <link value="speakLink"/>
          <link value="differentVoice"/>
          <speechRate value="500"/>
          <pitch value="0.8"/>
          <volume value="0.5"/>
        </screenReaderGeneric>
     </screenReader>
     <braille>…</braille>
    </display>
    <control>
       <keyboardEnhanced> …
       </keyboardEnhanced>
       <mouseEmulation>…</mouseEmulation>
       <voiceRecognition> …
       </voiceRecognition>
    </control>
</context>
</accessForAll>
...
```

Figure 7 - IMS ACCLIP in scenario C

```
[sfa:BProfile]
 |
 +-ccpp:component->
        [sfa:TerminalHardware]
 |       |
 |       +-rdf:type-->[sfa:HardwarePlatform]
 |       +-ex:displayWidth----> "1024"
 |       +-ex:displayHeight---> "768"
 |       +-sfa:audio----------> “yes”
 |       +-sfa:imagecapable---> “yes”
 |       +-sfa:brailledisplay-> “yes”
 |       +-sfa:keyboard-------> “yes”
...
```

Figure 8 – CC/PP Hardware Platform Component Profile in Scenario C

6. CONCLUSIONS

E-learning systems represent a fundamental means to offer educational services to people with disabilities, who typically have difficulties to attend traditional on-site learning programs or to gain access to traditional printed learning materials. Moreover, mobile e-technologies represent effective means to match skills of disabled learners and requirements/demands of the environment surrounding them, because of devices limited capabilities.

Even if adequate technologies have been already produced which are able to describe users and devices characteristics, yet, none of these solutions is really effective in capturing all these characteristics together.

We have presented a practical approach, which enables to fully profile e-learners. The idea at the basis of our approach is taking into consideration both physical human needs of the user and technical characteristics of the device he/she uses. The profiling method we devised has been included into a Web-based e-learning platform we developed which is able to dynamically adapt e-learning materials. Examples coming from real use cases have been provided, which confirm the viability of our approach.

```
...
+-ccpp:component->
         [sfa:TerminalSoftware]
 |        |
 |      +-rdf:type---> [sfa:SoftwarePlatform]
 |      +-ccpp:defaults---> [sfa:SWDefaults]
 |      +-sfa:name->“Windows XP Professional”
...
 |      +-sfa:tool-------->[ ]
 |      |                   |
 |      |  -----------------
 |      |  |
 |      |  +--rdf:type---->[rdf:Seq]
 |      |  +--rdf:_1------>“jaws7.0”
...
 |      +-sfa:audio------>[ ]
 |      |                  |
 |      |  ----------------
 |      |  |
 |      |  +--rdf:type-->[rdf:Bag]
 |      |  +--rdf:_1---->“wav”
 |      |  +--rdf:_2---->“mp3”
 |      |  +--rdf:_3---->“wma”
 |      |  +--rdf:_4---->“mid”
 |      |  +--rdf:_5---->“ra”
 |      |
 |      +-sfa:video------>[ ]
 |      |                  |
 |      |  ----------------
 |      |  |
 |      |  +--rdf:type--->[rdf:Bag]
 |      |  +--rdf:_1----->“avi”
 |      |  +--rdf:_2----->“mpeg”
 |      |
 |      +--sfa:SMILplayer->[ ]
 |      |                   |
 |      |  -----------------
 |      |  |
 |      |  +--rdf:type->[rdf:Bag]
 |      |  +--rdf:_1--->“RealOne”
 |      |  +--rdf:_2--->“QuickTime”
 |      |
...
```

Figure 9 - CC/PP Software Platform Component Profile in Scenario C

7. ACKNOWLEDGMENTS

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```
...
 +-ccpp:component-->
       [sfa:TerminalBrowser]
        |
        +-rdf:type---------> [sfa:BrowserUA]
        +-ccpp:defaults----> [sfa:UADefaults]
        +--sfa:name------>"Internet Explorer"
        +--sfa:version---------> "6.0"
        +--sfa:javascriptversion-> [ ]
        |                           |
        |  ------------------------
        |  |
        |  +--rdf:type---> [rdf:Bag]
        |  +--rdf:_1-----> "1.1"
...
        |
        +--sfa:CSS------------> [ ]
        |                         |
        |  ----------------------
        |  |
        |  +--rdf:type---> [rdf:Bag]
        |  +--rdf:_1-----> "2.0"
...
        |
        +--sfa:htmlsupported---> [ ]
        |                         |
        |  ----------------------
        |  |
        |  +--rdf:type---> [rdf:Bag]
        |  +--rdf:_1-----> "3.2"
        |  +--rdf:_2-----> "4.01"
        |
        +--sfa:mimesupported---> [ ]
        |                         |
        |  ----------------------
        |  |
        |  +--rdf:type---> [rdf:Bag]
        |  +--rdf:_1-----> "text/html"
        |  +--rdf:_2-----> "text/plain"
        |  +--rdf:_3-----> "text/css"
...
        |
           +--sfa:language--------> [ ]
                                      |
              ----------------------
              |
              +--rdf:type---> [rdf:Seq]
              +--rdf:_1-----> "it"
```

Figure 10 - CC/PP Browser User Agent Component Profile in Scenario C

8. REFERENCES

[1] DELI: A Delivery Context Library For CC/PP and UAProf. Available from: http://delicon.sourceforge.net/, 2007.

[2] Harrison, L. and Treviranus, J. Accessible E-Learning - Demystifying IMS Specifications. In *Proceedings of World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education (ELEARN '03)*, 2003, 2000-2003.

[3] IMS Global Learning Consortium. Available from: http://www.imsglobal.org, 2007.

[4] IMS Global Learning Consortium. IMS AccessForAll Meta-data Specification. Available from: http://www.imsglobal.org/specificationdownload.cfm, 2002.

[5] IMS Global Learning Consortium. IMS Learner Information Package Accessibility for LIP. Available from: http://www.imsglobal.org/specificationdownload.cfm, 2002.

[6] IMS Global Learning Consortium. IMS Learner Information Profile (LIP). Available from: http://www.imsglobal.org/specificationdownload.cfm, 2002.

[7] Nevile, L., Rothberg, M., Cooper, M., Heath, A. and Treviranus, J. Learner-centered Accessibility for Interoperable Web-based Educational Systems. In *Proceedings of Interoperability of Web-Based Educational Systems Workshop, 14th International World Wide Web Conference (WWW2005)*, 2005.

[8] Open Mobile Alliance (OMA). User Agent Profile v. 1.1 Approved Enabler. Available from: http://www.openmobilealliance.org/release_program/uap_v11.html, 2002.

[9] Salomoni, P., Mirri S., Ferretti, S. and Roccetti, M. A Multimedia Broker to support Accessible and Mobile Learning through Learning Objects Adaptation. To Appear in *ACM Transactions on Internet Technology* (Jan. 2007).

[10] Savidis, A. and Stephanidis, C. Developing inclusive e-learning and e-entertainment to effectively accommodate learning difficulties. In *ACM SIGACCESS Accessibility and Computing*, 83 (Sep. 2005), 42-54.

[11] Seale, J. The development of accessibility practices in e-learning: an exploration of communities of practice. In *ALT-J Research in Learning Technology, 12*, 1 (Mar. 2004), 51-63.

[12] Sun Microsystem Inc. JSR 188: CC/PP Processing. Available from: http://www.jcp.org/en/jsr/detail?id=188, 2007.

[13] The Inclusive Learning Exchange (TILE). Available from: http://www.barrierfree.ca/tile/, 2007.

[14] Web-4-All Project. Available from: http://web4all.atrc.utoronto.ca/, 2007.

[15] World Wide Web Consortium. Composite Capability/Preference Profiles (CC/PP): Structure and Vocabularies 1.0. Available from: http://www.w3.org/TR/2004/REC-CCPP-struct-vocab-20040115, 2004.

[16] World Wide Web Consortium. Synchronized Multimedia Integration Language 2.1. Available from: http://www.w3.org/TR/2005/REC-SMIL2-20051213/, 2005.

[17] WURFL. Wireless Universal Resource File Library. Available from: http://wurfl.sourceforge.net, 2007.