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LONG PAPER

Carlos A. Velasco · Yehya Mohamad · Alfred S. Gilman
Nikos Viorres · Evangelos Vlachogiannis
Argyris Arnellos · Jenny S. Darzentas

Universal access to information services—the need for user information and its relationship to device profiles

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Abstract Users access information services with a variety of devices and with different interaction modes that depend on personal characteristics (including disabilities) and on the context of usage. With the appearance of mobile devices, the industry has focused its efforts on the standardization of device characteristics, thus giving to information providers some content adaptation facilities. However, little attention has been paid to the standardization of user profiles that will allow further customization and adaptation capabilities in mainstream services. This paper will present the authors' experiences in outlining and implementing user profiles, as well as possible integration paths with device characteristics.

Keywords Assistive technology · Internet · Universal access · Usability · User interface

1 Introduction

It is commonly accepted that universal access to information services depends upon the adaptation and customization of content and presentation. This paper presents an approach that tackles the adaptation process. Parts of these adaptations have been developed under the umbrella of IRIS[1] project [8] through the combination of user and device profiles, based on the Composite Capabilities/Preferences Profiles framework (CC/PP) [5], via a client-side proxy, together with server-based adaptations.

The underlying principles of our efforts are based upon the following premises:

– Information about user factors, and not just device factors, must be included in the adaptation of service delivery mechanisms to obtain access to these services for all people, particularly for people with disabilities.
– Neutral, and preferably standard, terms are required for expressing user interface device characteristics and user needs and preferences to allow service adaptations to respond appropriately to the user's needs and preferences when the user is operating in the context of those devices [17].
– The CC/PP framework developed by the W3C[2] is a suitable means of communicating user and device demand-side characteristics to adaptable Web applications, if augmented with additional vocabulary in the user needs and preferences realm.

1.1 The need for user information

The user and the adaptation process need to be able to converse, when the adjustment from a general purpose initial profile or interface binding fails to work. This interaction shall not require so many individual adjustments (as it might be the case for a user with sufficiently severe functional impairments) that improvement or degradation of the interface is not obvious to the user. An example of a functional impairment where custom-

C. A. Velasco (✉) · Y. Mohamad
Fraunhofer-Institut für Angewandte Informationstechnik (FIT), Schloss Birlinghoven, 53757 Sankt Augustin, Germany
E-mail: Carlos.Velasco@fit.fraunhofer.de

A. S. Gilman
1101 S. Arlington Ridge Road, #712, Arlington VA 22202-1926, USA

N. Viorres · E. Vlachogiannis · A. Arnellos · J. S. Darzentas
Department of Product and Systems Design, University of the Aegean, Ermoupolis, Syros, GR83200, Greece

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[2] World Wide Web Consortium, http://www.w3.org/.

ary interfaces are unusable, and hence incremental repair fails, is the situation of persons with attention deficit disorder confronted with a typical Web-shopping home page [2]. An example where the parametric adjustments are too numerous for the incremental change process to reliably find its way to a feasible set, concerns people with severe but not total vision loss using a representative atlas (map) application [16]. A third case where systematic description of needs and preferences is indicated, is when significant morphological changes need to take place to reach the best accommodation. One example of this has to do with low-vision users of screen magnifiers. Here, horizontal scrolling to read lines of text that reach off the screen is a major obstacle to usability. Text should be wrapped within the limits of the actual field of view of the user if at all possible, irrespective of whether this boundary is set by the surrounding content on the layout canvas, by the borders of the visible area after screen magnification, or by the limits of the user's own field of view being significantly smaller than the extent of the physical display screen. In such a situation it would be better to take a personal digital assistant (PDA) or cell phone layout template as the master topological layout of the material, rather than the more pane-rich layout typically used with a device of a large pixel size. Similarly, users with severe learning disabilities need dialog processes to be simplified to a few choices at a time, as in a voice dialog, and to not be assaulted by a welter of attention-seeking subdisplays, as is typical on the Web today [2]. Here, the morphological transformation is in the state transition graph geometry of the dialog, and not in the instantaneous geometry of the concurrent information display.

The point of these examples is that there are some people with disabilities who can be served within the un-extended range of the adjustment of adaptable services, but not without systematic tools to characterize their needs. There is in addition considerable interest in the general information products and services industry towards some way of attaining persistent and portable personal preferences, so that users would be able to deal with newly encountered resources within the comfort of their own climate of preferred adaptations. Such portability could be achieved via Web Services [15].

1.2 The need for neutral terms

Information services, especially as accessed across the Web, are developed through a large number of independent activities. The user's needs may be familiar to their personal equipment, and in particular may be pretty well indicated by the settings on the interfaces that they routinely use. However, the presence of assistive add-on technologies, and the settings of the mainstream and assistive technology components are not covered in the terms defined in the UAProf vocabulary [14] presently available for use in the CC/PP framework to guide adaptation to mobile devices by Web servers.

As the user needs and preferences gathering/assessing applications and the service adapting engines are developed by different parties, a common language is needed to enable the adaptations performed by the server to address the needs and preferences known to the client. That is to say that a mutual meta-language is required if one wants to improve what can be done by separate trial-and-error training periods with each service. The latter can be tolerated where personalization is a frill, and only used on a few sites that one visits often. For the person with certain disabilities, the meta-dialog is the only way to reach a viable adaptation, and the neutral language for the necessary degrees of freedom is essential.

1.3 The CC/PP framework

In the last 20 years, several generic user modeling systems have been developed to allow adaptation in different software applications [6]. Most of these developments were either academic, never reached the commercial arena, or had very little impact in mainstream software (mainly with very limited customization options in mainstream operating systems). With the explosion of the Web, and e-commerce in particular, several commercial user-modeling tools appeared in the market with the objective of adapting content to user tastes and preferences. There are attempts to characterize user preferences, as, for example, the CEN standard for the smart card encoding of user interface preferences.[3] The emergence of mobile devices has led as well to the appearance of device description vocabularies such as UAProf to provide some basic content adaptation capabilities.

The CC/PP framework offers the possibility to define user and device profiles for an adequate adaptation of content and presentation of Internet services. The CC/PP framework is based upon the Resource Description Framework (RDF) [9], a general-purpose metadata description language. The RDF provides basic tools for both vocabulary extensibility, via XML namespaces and interoperability, and can be used to represent entities, concepts and relationships on the Web. In later sections, we will present an overview of some preliminary implementations of these profiles, and the adaptation process within the IRIS project [7].

1.4 Normalizing the interface

The INCITS/V2 standards committee working on the Alternate Interface Access Protocol [1] family of standards is aware of the fact, discussed above, that knowledge of service adjustability is available in one activity and knowledge of factors affecting the optimization of the concrete-interface binding of the service is

[3] http://www.tiresias.org/reports/en1332_4.htm

available somewhere else. Neutral terms are ideally needed to bring these together. In its initial application scenario, the architecture of the universal remote console specification (AIAP) [17], the issue is dealt with by having the service expose a highly robust characterization of its operational interface, that is then adapted by the remote console, which is a personal device of the user's choice. These devices can be specially purposed in terms of user needs, and the accommodation of bindings makes the characterization of the service so robust that adaptation can be performed entirely by the client. The client knows its user and how it is generating a concrete interface binding. Therefore, the user factors can be expressed in terms private to the client implementation, and not shared with the server.

However, the need for better terms characterizing the adaptation space is recognized in the V2 work as required in cases other than the remote console case, and there is ongoing work in this direction.

2 The integration of user and device profiles. Content metadata

The motivation for integrating user and device profiles is to create a mechanism that enables users to access information in a way that is best suited to their needs. These needs may be permanent, that is, due to a condition that will not change, such as a disability, or may respond to temporary context-based handicapping situations (hands-free operation, noisy environments, inability to access usual input devices, etc.). Within the IRIS context, this information is used to adapt presentation and navigation features. However, the aim of the project is to develop a flexible framework that can allow content adaptation as well.

In regard to content adaptation, there is another strand of work that is contingent to the work described in this paper, that of accessibility metadata. In order for the user and device profile integration to be useful, the content delivered must be also meaningful for the users. However, there is a strong case for claiming that users will also want to be aware of content, even if it is something that is not directly accessible to them, according to their device and user profile. After all, they may be able to change access devices, or even ask the author of the content to supply an accessible equivalent or alternative. Therefore, before users embark on downloading, negotiation between the content metadata and the device could take place, to ensure that the resource can be rendered.

Efforts in this area are still very fragmented with several groups working somewhat independently, as well as some confusion over what can be meant by accessibility [12]. For example, for some groups, accessibility is the right of access to documents, or the accessibility of the Dublin core itself. There are also other important issues linked to accessibility, such as the fact that resource discovery can be as important as downloading the resource. The Dublin Core Accessibility Group[4] is working to understand these different contributions, to bring their work together,[5] and to elaborate in the future a metadata profile for accessibility, examples, and guidelines for accessibility metadata. At present there is no well-specified format for a description of the accessibility of a piece of content or "resource", for general purposes. There is considerable impetus from the IMS project[6] to release specifications for standards of the Learning Object Metadata (LOM). As online courses are being accessed increasingly by learners with disabilities, it is important that the user profile, known as the Learner Information Profile (LIP), which is designed to be used by the learner as he travels through systems, enrolls in classes, participates in courses and undergo assessments, can also register particular needs to be accommodated. IMS is still in the process of determining just how the LIP will characterize accessibility needs and how they will be related to, and matched with, accessibility metadata profiles for resources and services.

Therefore, given this state of affairs, it is reasonable to expect that as work on user and device profiles continue, these will contribute both requirements and solution strategies to the descriptions needed for matching resources to users and devices, i.e., the accessibility metadata.

2.1 The identification of domains

Our integration approach recognizes different actors that intervene in the use of Internet services. We identified the following actors: the user, the access device (including the user agent), the content, the application to deliver the content and the author. The inclusion of the authoring process lies outside the scope of this paper, and presents interesting challenges, especially when addressing the issue of device-independent authoring [11]. These actors are represented by different abstractions:

- The user profile. Compilation of different information aspects associated with the user, e.g., personal data, functional characteristics and interaction preferences. It may also include information about the context of use (either automatically acquired such as a GPS location, or given by the user).
- The device profile. Summary of device characteristics including the hardware, the software, the operating system, etc. We foresee a dependence relationship between these two profiles where blending or user and device characteristics take place.
- The application abstraction. Compilation of the properties of the application related to its functionality and interface characteristics. This aspect is partially covered under the scope of IRIS, as we are

[4] http://dublincore.org/groups/access/standards.html
[5] http://dublincore.org/groups/access/workshop-20021017.html
[6] http://www.imsproject.org/

dealing only with content presentation issues. We do not foresee a universal application abstraction mechanism, but it might be feasible to develop some standards for generic types of applications [1].
– The content metadata. See the previous section.

2.2 The device profile

The CC/PP framework does not define by itself a vocabulary to represent user or device profiles. It is a powerful framework to develop such vocabularies. Up to now, the only implementation of the CC/PP framework is the User Agent Profile (UAProf), by the Open Mobility Alliance (formerly the WAP-Forum) and targeted to mobile devices [14]. UAProf has a very specific scope and cannot cover the whole spectrum of devices that can access Internet services and applications nowadays, nor it can address user characteristics. Its key components (as described in the specification—additional components can be added) are:

– **HardwarePlatform**: A collection of properties that adequately describe the hardware characteristics of the terminal device. This includes the type of device, model number, display size, input and output methods, etc.
– **SoftwarePlatform**: A collection of attributes associated with the operating environment of the device. Attributes provide information on the operating system software, video and audio encoders supported by the device, and the user's language preference.
– **BrowserUA**: A set of attributes to describe the HTML browser application.
– **NetworkCharacteristics**: Information about the network-related infrastructure and environment. These attributes can influence the resulting content, due to the variation in capabilities and characteristics of various network infrastructures in terms of bandwidth and device accessibility.
– **WapCharacteristics**: A set of attributes pertaining to WAP capabilities supported on the device. This includes details on the capabilities and characteristics related to the WML Browser, WTA,[7] etc.
– **PushCharacteristics**: A set of attributes pertaining to Push specific capabilities supported by the device. This includes details on supported MIME-types,[8] the maximum size of a push-message shipped to the device, the number of possibly buffered push-messages on the device, etc.

UAProf presents two additional problems. Firstly, mainstream desktop operating systems and user agents do not implement any CC/PP profiles, which forces us to generate some client-side proxy-based implementation of our device profile. Secondly, we need to be able to include in the device profile alternative I/O devices (input switches, Braille-lines, etc.) and assistive technology software (speech-recognition software, on-screen keyboard, etc.).

The CC/PP framework foresees the possibility to integrate in a single vocabulary user and device profile. Although this approach is feasible, we opted to separate software/hardware components from user preferences, as the user could access the same service using different devices. This approach will help future implementations based upon Web Services, the introduction of multimodal interfaces, and the standardization of profiling information.

The selected approach is based upon four of the sections of UAProf. The specific sections WAP- and PushCharacteristics are not used, as from our point of view they can be integrated within the relevant network characteristics. The novelty lies in extending the basic Hardware- and SoftwarePlatform to emphasize the interaction aspect by adding specific input and output components. These components can then contain information relevant to assistive technologies (earlier implementations can be found in [7, 15]).

– **HardwarePlatform**. The hardware description of the platform where the user agent runs. It includes information on CPU type and speed, memory size, display size and color depth, keyboard and mouse, supported character sets, network and modem capabilities, Bluetooth and other wireless functionalities, etc. Subcomponents are defined grouping information related to input (**InputDevices**) and output devices (**OutputDevices**), where assistive technology elements such as input switches, head-mice, biosensor-control systems, eye-gaze trackers, Braille-lines, etc., may be included besides traditional I/O hardware.
– **SoftwarePlatform**. Generic information about the operating system run by the device. It includes generic properties, such as the OS name, the version and manufacturer. Similarly, we added subcomponents to group input software (**InputSoftware**, e.g., speech-recognition, on-screen keyboard, mouse emulators, etc.) and output software (**OutputSoftware**, e.g., a screen-reader).
– **UserAgent**. Information about the browser manufacturer and version, markup supported, styling and scripting languages, and MIME-type rendering capabilities. Information about plug-ins and media players linked to the agent is also contained.
– **NetworkCharacteristics**. Global information about the network to access the Internet application: bandwidth, proxies and firewalls, WAP-related info, etc.

2.3 The user profile: the blending approach

As mentioned earlier, we defined a user profile based on the CC/PP framework. The design of the profile con-

[7] Wireless Telephony Application Specification, defined also by the Open Mobile Alliance.
[8] ftp://ftp.isi.edu/in-notes/iana/assignments/media-types/

siders the following constrains (earlier implementations can be found in [7, 15] as well):

- Compatibility with traditional profiles that store personal and demographic data, as well as typical user-management information (username, password, etc.).
- Ability to store information related to the application's functionality.
- Capability to store information about the delivery context (context of use).
- Facility to translate user profile components to device profile components and application abstraction components. It is a key issue that the user profile can override or modify device characteristics. This is what we call a blending process to express priorities [4].

A generic vocabulary would be able to consider not only the relationship between user abilities and device properties and methods, but to also include relationships of user abilities with abstract application models. This was beyond our resources. As a test framework, not exempt of commercially appealing value, we focused on designing a user profile that can be matched directly to the device profile, plus some additional components that are equivalent to some parameters typical of Internet applications. The defined components are:

- **PersonalInfo**. Personal data of the user (grouped under the **PersonalData** subcomponent). It may also contain demographic data of interest (e.g., marital status, income level, etc.; the **DemographicData** subcomponent) and user-management information related to the Web application (e.g., username, password, favorite sections, etc.; the **AdminData** subcomponent).
- **InputPrefs**. User preferences regarding input modes. It includes a parameterized list of input modes to be matched with the device profile and the delivery context, together with some management options. For example, a user with a severe physical disability might express as her preferred input mode an infrared mouse and an on-screen keyboard (available in her desktop), whereas when using her PDA attached to her wheelchair, she might set her preferences to an electromyogram-biosensor connected to her right cheek together with another on-screen keyboard.
- **OutputPrefs**. User preferences regarding output modes. It includes a parameterized list of output modes to be matched with the device profile and the delivery context as well. For the same user described above, her preferred output mode might be the display, but when using the PDA, due to its small screen size, she might prefer speech output.
- **InteractionPrefs**. User preferences regarding navigation (the **Navigation** subcomponent), search (the **SearchPrefs** subcomponent) and information highlighting (the **Highlighting** subcomponent). Typical examples include the presence of breadcrumb-navigation information, the absence of Javascript roll-out menus, user-defined stylesheets, a pre-defined set of accesskeys for important Web site landmarks, the use of advance search facilities that include Regular Expressions, the visual or oral highlighting of application sections based upon keywords and other metadata elements (e.g., author, date of publication...), and others.
- **DeliveryContext**. It includes location and time awareness (the **Location** subcomponent). This subcomponent might be acquired automatically (e.g., via a GPS-enabled mobile phone), or with the intervention of the user. This type of information is important to modify dialog modes with the application (e.g., an information kiosk in a noisy environment such as a shopping mall, that does not permit any speech-based interaction). The DeliveryContext component may include biometrical data, in which the user's emotional status can play an important role (**EmotionalStatus** subcomponent [10, 13]). This information can certainly be used to adapt and improve human-computer communication. However, the tracking of emotions is complex, and the authors are investigating the use of biofeedback sensors for this task.[9]

It is important to highlight that both profiles contain sensitive information in regard to the personal situation of the user and her functional impairments. That could potentially affect the user's acceptance of the system. Therefore, security and privacy issues need to be addressed.

2.4 An implementation: blending user and device profiles in IRIS

The IRIS project has as one of its goals that of assembling various strands of work regarding Internet-based systems and services, their usability and accessibility aspects, and making this knowledge useful and accessible to designers of such services and systems. One of the ways followed to achieve this goal is the creation of a Design Support Environment, the IRIS DSE. We aim to achieve this by combining user and device profiles, to ensure that the presentation of the environment is suitable for the designer, whether she has a disability or not. Our implementation is based on two elements:

- A client-side proxy that compiles information about the client device and, by interacting with the user, elaborates a user profile; and
- Server-side processing of information to render adapted content based upon the aforementioned profiles.

Fig. 1 illustrates our approach as an iterative process of translating user-related technical characteristics to the communication channels to which the application needs

[9] The IPCA (Intelligent Physiological Navigation and Control of Web-based Applications) project (IST-2001–37370). http://www.ipca.info/

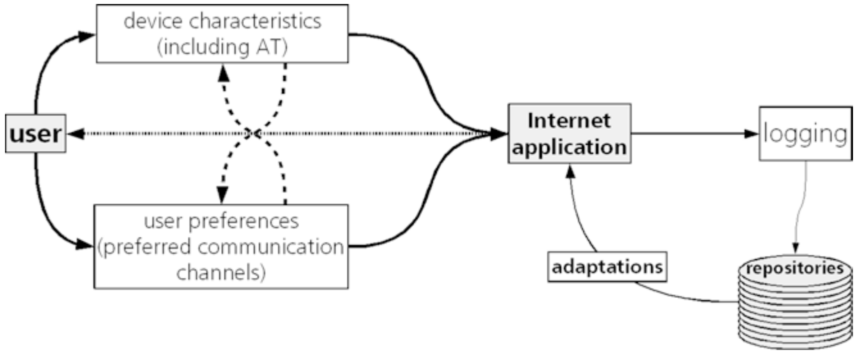

Fig. 1 Actors and their relationships in the adaptation process of IRIS. The user sets her profile in the enrollment process, that is sent together with the device profile to the application server. The server processes the received information and can deliver an appropriate view of the content. The established logging facility can be used in the future to enhance the adaptivity of the application

to conform to. The acquisition and generation of profiles is related to the user enrollment process. Typically, the enrollment process has two steps, each of them related to acquiring information related to the access device and user-related preferences and characteristics. User enrollment starts as soon as the user connects to the IRIS DSE application. Then, user and device profiles are blended and sent to the application server for processing, which can deliver an adequate view of the content to the user. Parts of the device profile are automatically retrieved using the developed CC/PP proxy, located at the client side (a screenshot of the prototype implementation of this step of the enrollment process is shown in Fig. 2). Future work is oriented to improve the logging mechanism to implement application adaptivity.

The user profile is generated:

– explicitly by the user (‘‘manually’’, with system help);
– by the application interacting with the user, through inheritance of a predefined stereotype.

It is important to note that the initial profile proposed to the user must be within a feasible set of parameters, to allow her their manipulation and fine-tuning [16]. For that purpose, stereotypes describing certain user categories are created (a similar approach to [3]). Each stereotype describes a certain user profile category, in terms of the characteristics of the respective communication channels that better fits her, while, in parallel, it associates these specific user characteristics with the respective representational parameters of the content: formatting, scaling and timing parameters.

Within IRIS, stereotypes are implemented by sets of templates and stylesheets. The stereotype has to be selected on the basis of the system knowledge about users' preferences. This knowledge is represented in the form of rules that map generic profile characteristics to presentation vehicles. A formal example of these rules could be as follows:

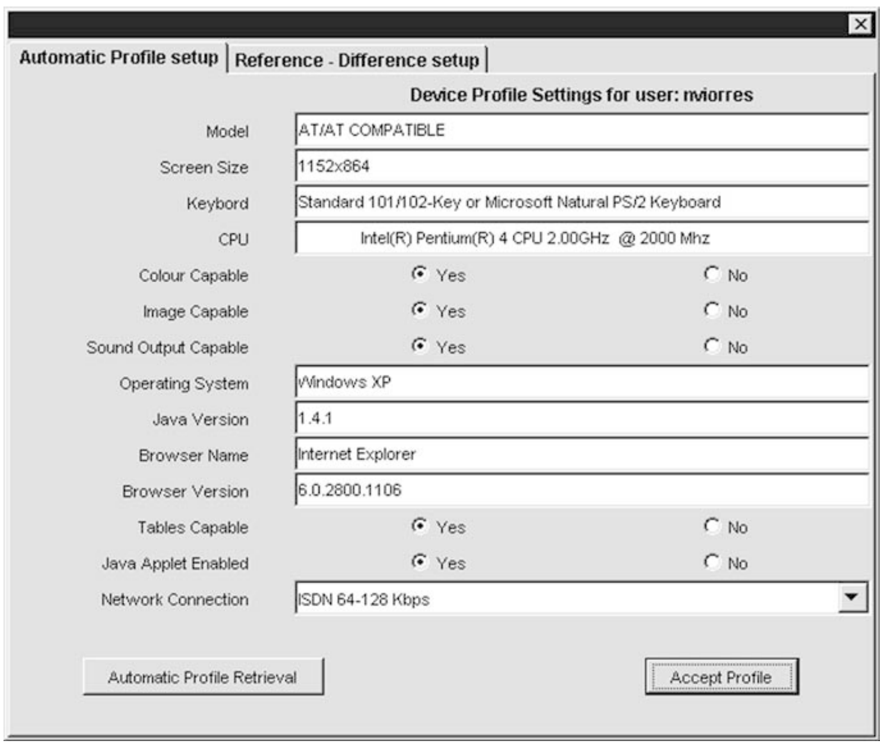

Fig. 2 A screenshot of the prototype implementation of the client-side proxy. The figure presents the acknowledgement of the device profile during the IRIS DSE enrollment process

If{$X \in$ [x1, x2])and(Y $\in$ [y1, y2]) and(Z$\in$[z1,z2]) and(...)}then suggest stereotype N

where *X, Y* and *Z* are user or device characteristics; x_i, y_i and z_i are different range values or parameters; and *stereotypeN* is one of the basic stereotypes.

The mapping mechanism is complex, and the decision-making process needs to be validated via user testing. The system must be able to provide a sensible initial presentation from the *N* set of available stereotypes (i.e., template/stylesheet combinations). User-defined fine-tuning can be implemented, and some further automatic adaptivity of the system can be explored on the basis of user interaction with the system, by inheritance of one of the aforementioned stereotypes. This can be implemented through the usage of accumulated statistical information regarding the profile-type/template-index pair.

This mapping must avoid falling into typical misconceptions about how users interact with the Internet. For example, it might be argued that a user that scans Web pages with a "peephole" viewer, such as a refreshable Braille display, will not care about font sizes. However, the case is that many users of these systems set the font size to a minimum to get the maximum content into a static frame over which they move the Braille line inspection window. In that way, they minimize the number of times they have to redefine the background coordinates with regard to which they move the viewing window. Another typical use case for the mapping of user characteristics has been offered in the Introduction section, where it was shown that users with visual impairments are better served by layouts used for PDAs or mobile phones.

3 Conclusions and future work

The ideas and work presented in this paper represent work in progress. We have shown that the standardization of user and device information, together with a sound blending process, leads to a better adaptation of the content presentation in Internet services. There are several directions that our future work will take. An ideal scenario will consist of standard vocabularies able to consider not only the relation of user and device features, but to include relationships with abstract application models and content metadata. Within this scenario, Internet service providers will be able to develop adaptation mechanisms that fit their needs. Then, universal access will be a natural result of customized content and presentation.

This architecture can be distributed and extended via the inclusion of Web Services delivering relevant information to content providers and ISPs. This development, of course, raises important concerns about privacy and security issues that need to be addressed alongside the purely technological work, and can affect a user's acceptance of the system.

Further work is ongoing by the authors in the area of user stereotyping and user testing of the system, blending mechanisms of user and device information by software agents, the inclusion of the user's emotional response and interface abstraction. Hopefully, this work will contribute to developments in the area, and facilitate the goal of universal access.

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