From User interfaces for all to an Information Society for All: Recent achievements and future challenges

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Abstract. *User Interfaces for All* has been defined as a systematic approach to the design, implementation and evaluation of user interfaces that cater for the requirements of the broadest possible user population. The scope of *User Interfaces for All*, as a perspective on HCI, is necessarily broad and complex, involving challenges, which pertain to issues such as context-oriented design, diverse user requirements and adaptable and adaptive interactive behaviors. This paper attempts to address a two-fold objective: first, to review the premises of *User Interfaces for All* and how they have been realised by recent technical accomplishments; secondly, to sketch a transition towards an Information Society for All, by pointing out some of the challenges involved, and how they are being addressed by on-going work.

1. INTRODUCTION

The concept of *User Interfaces for All* (UI4All) was originally introduced in 1995 (Stephanidis, 1995a), following the results of several research initiatives in the context of collaborative project work partially funded by the European Commission (a review is available in Stephanidis and Emiliani, 1999). Since then, the principles underlying UI4All have been taken up in a number of European and international collaborative research activities, which, over the years, have created a momentum and attracted the interest of the research and academic community, as well as of the industry. For example, last year NSF launched a new research programme on universal access, while the European Union re-formulated its commitment towards an all inclusive Information Society by introducing *design for all* as an explicit research target in its 5th Framework Programme, and more recently by adopting the e-Europe initiative “Towards an Information Society for All”.

In this paper, we attempt to illustrate the link between UI4All and the notion of an Information Society for all, the former being a prerequisite for the latter. To this effect, we first review the premises of *User Interfaces for All*, their subsequent translation into technical propositions and the results of collaborative R&D project work, which substantiated early proposals. Then, we discuss future challenges towards an Information Society for all and provide insights into how some of these challenges are being taken up by on-going activities. The objective is to highlight success stories of the recent past, as well as to enumerate critical activities and research targets to be attained in the future.

The paper is structured as follows. In the next section we provide a review of the concept of *User Interfaces for All* and of its historical roots and motivation, as well as of the underlying technical work. Then, we examine future challenges towards an Information Society for all and review research activities, which have been initiated to advance the concept of *User Interfaces for All* into new stages and to widen the scope and applicability of the underlying premises.

2. THE CONCEPT OF USER INTERFACES FOR ALL

User Interfaces for All is rooted in the concept of Design for All in HCI, and aims at efficiently and effectively addressing the numerous and diverse accessibility problems in human interaction with software applications and telematic services (Stephanidis, 2001a). The underlying principle is to ensure accessibility at design time, and to meet the individual requirements of the user population at large, including disabled and elderly people. To this end, it is important that the needs of the broadest possible end-user population are taken into account from the early design phases of new products and services. Such an approach eliminates the need for 'a posteriori' adaptations and delivers products that can be tailored for use by the widest possible end-user population.

2.1 From concept to implementation

The ACCESS[1] project, in the course of a three-year effort, aimed to develop new technological solutions for supporting the concept of *User Interfaces for All*, i.e., universal accessibility of computer based applications, by facilitating the development of user interfaces capable of automatically adapting themselves to individual user abilities, skills, requirements, and preferences. The project developed the *Unified User Interface* development methodology (Stephanidis et al., 1997; Akoumianakis et al., 2000; Stephanidis; Savidis and Stephanidis, 2001a, Savidis and Stephanidis, 2001b; Savidis et al., 2001), and delivered a novel user interface development platform (Akoumianakis and Stephanidis 2001, Savidis and Stephanidis, 2001c).

2.1.1 Unified interfaces

A Unified User Interface (see Figure 1) has been defined as an interactive system that comprises a single (i.e., unified) interface specification, targeted to potentially all user categories and contexts of use. Such a specification can be built using either a traditional programming language, or a dedicated language.

[1] The ACCESS TP1001 (Development platform for unified ACCESS to enabling environments) project was partially funded by the TIDE Programme of the European Commission, and lasted 36 months (January the 1st, 1994 to December the 31, 1996). The partners of the ACCESS consortium are: CNR-IROE (Italy) - Prime contractor; ICS-FORTH (Greece); University of Hertforshire (United Kingdom); University of Athens (Greece); NAWH (Finland); VTT (Finland); Hereward College (United Kingdom); RNIB (United Kingdom); Seleco (Italy); MA Systems & Control (United Kingdom); PIKOMED (Finland).

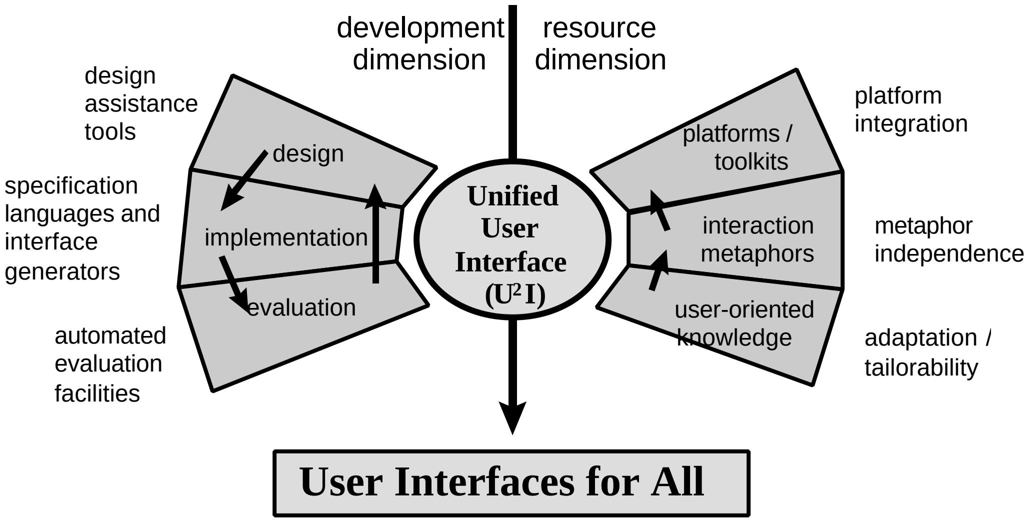

Figure 1. The concept of unified user interfaces

The distinctive property of a Unified User Interface is that it can realise alternative patterns of interactive behaviour, at the physical, syntactic or even semantic levels of interaction, by automatically adapting to accommodate specific user- and context-oriented requirements. Typically, such alternative interactive behaviours encompass interaction elements available in different toolkits or interaction platforms (e.g., Windows95, toolkit for non-visual interaction), suitable for the different target user groups (e.g., sighted and blind users respectively).

The design of interactive software applications and telematic services accommodating the requirements of "all" users in different contexts of use introduces the need to take into consideration the diverse attributes that characterise these users and contexts. These varying user- and usage-context- attributes give rise to different design requirements and constraints, which, in turn, affect the design of dialogue artefacts. As a result, the differing values of user- and usage context- attributes dictate the construction of alternative dialogue artifacts at various points of the interface design process.

When trying to map the outcomes of such design processes into an implemented interactive application, a key issue is how the various alternative dialogue artefacts will be "packaged". The production of alternative interface versions requires prohibitive resources for development, maintenance, upgrading and distribution (since all distinct versions should potentially be made available for concurrent "execution"), and turns out to be practically unrealistic. This is particularly evident in the case of non-desktop computer systems, such as public access terminals, that anyone should be able to use. Consequently, the "packaging" of the various alternative dialogue patterns into a single software application has been considered the most promising approach. In this context, packaging may not necessarily imply the construction of a monolithic software system incorporating all the various dialogue artefacts; rather, it can be instantiated as a logical collection within a single resource. For example, a repository of dialogue patterns can be made directly accessible by a single software application that encompasses adaptation capabilities, thus being able to select the most appropriate dialogue patterns for a particular end-user and target usage context. In order to facilitate such a capability, interactive applications should also encompass information about individual users.

2.1.2 Unified interface development

Having briefly described the concept, this section presents the main points of a development strategy for Unified User Interfaces, namely Unified User Interface development. Further details on the technical properties of unified interface development are reported in (Savidis and Stephanidis, 2001a; Savidis and Stephanidis, 2001b, Savidis et al., 2001).

The Unified User Interface development paradigm entails inter-disciplinary processes driving the production of automatically adapted software applications and services. It is general enough, so as not to exclude particular design and implementation practices, while, at the same time, it offers sufficient details to drive the engineering process of Unified User Interface software. As any new development paradigm, it naturally requires some initial investment to be effectively adopted, assimilated and applied. Though the field lacks substantial data and comparative assessments as to the costs of designing for all, it has been argued that (in the medium- to long-term) the cost of inaccessible systems is comparatively much higher, and is likely to increase even more, given the current statistics classifying the demand for accessible products [Bergman and Johnson, 1995].

Schematically, the process of Unified User Interface development is depicted in the diagram of figure 2. Unified design entails an early account of the broadest possible range of end-user requirements and contexts of use, so as to develop effective representations depicting the global task execution context. Unified implementation, on the other hand, requires the capability to encapsulate design alternatives into suitable dialogue patterns and to map abstract design components to corresponding implemented (interaction platform-specific) options.

Two distinctive requirements characterise Unified User Interfaces. The first is the requirement for an analytical design activity leading to the representation of the design knowledge required to reveal and differentiate amongst plausible design alternatives. The second requirement is that of encapsulation of the corresponding dialogue patterns into a (conceptually) single interactive entity. In this context, representation implies the use of suitable notations to capture and encode both design artefacts and accompanying design rationale. On the other hand, encapsulation entails the use of suitable dialogue specification techniques (programmatic, declarative, etc.) to manipulate interactive artefacts in a manner that is not dependent on a particular target interaction platform (e.g., by avoiding direct “calls” to the platform’s interactive facilities).

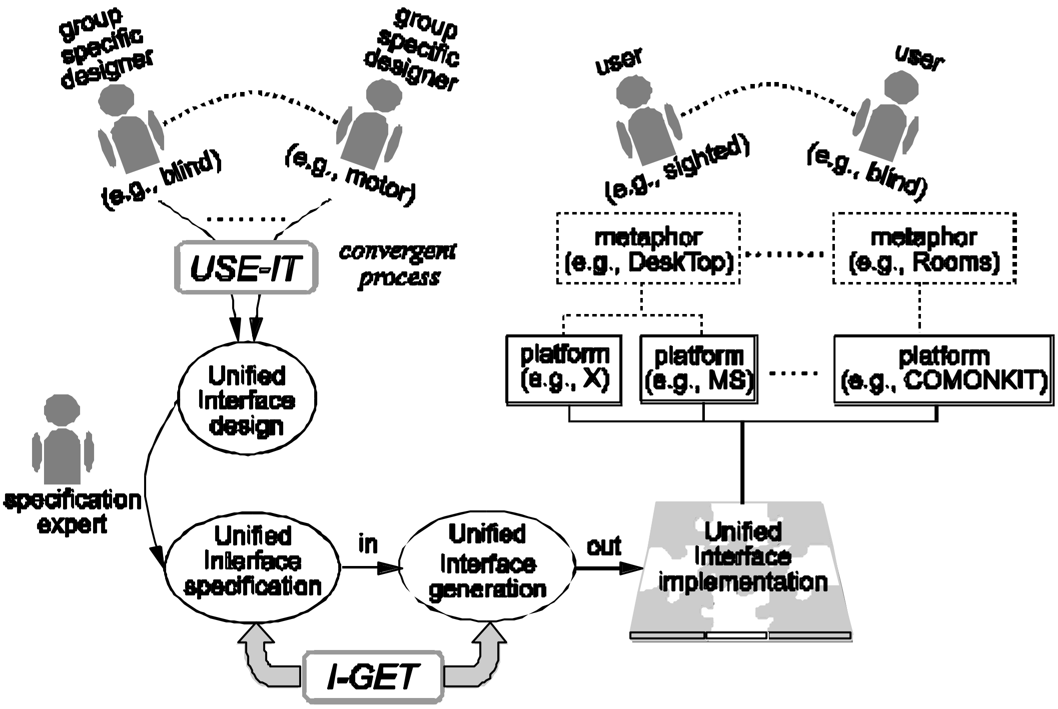

Figure 2. The design and implementation of Unified User Interfaces

The design of a Unified User Interface entails three distinctive iterative tasks, namely *enumeration of design alternatives*, *abstraction* towards reusable unified design components and *rationalisation* of the design space. *Enumeration* of design alternatives can be attained through techniques that foster an analytical design perspective (such as design scenarios, envisioning, ethnographic methods) and facilitate the identification of plausible design options for different user groups (i.e., design space).

Abstraction entails the identification of abstract interaction components that can be used to encapsulate alternative concrete artefacts. Such abstract components are de-coupled from platform-, modality-, or metaphor-specific attributes to provide a kind of reusable design "library". Such an abstract element can be subsequently mapped to any particular concrete instance, given a specific user and context of use. Moreover, abstract components may be used to compile composite interface elements suitable for different users and contexts of use.

Finally, rationalisation of the design space implies the explicit encoding of the rationale for mapping an abstract design element to a concrete artefact. This is typically achieved by assigning criteria to design alternatives and providing a method for selecting the maximally preferred option.

To facilitate encapsulation, Unified User Interface development requires techniques that enable: (i) the grouping of alternative dialogue patterns (e.g., implemented design alternatives, catering for different user requirements) on the basis of an abstraction model; and, (ii) the context-sensitive mapping of abstract components to suitable concrete artefacts. To this effect, the process of Unified User Interface implementation involves: (a) the construction of a Unified User Interface as a composition of abstractions at different levels of interaction; (b) the manipulation and management of the physical resources (e.g., various toolkits); and, (c) the establishment of the relationships between the involved abstractions and the available physical resources.

The unified implementation undertakes the mapping of abstract interaction elements to concrete / physical resources available in the target toolkits. This is achieved through specific functionality or tools which enables the connection (or linking) with the underlying platform(-s) in order to utilise the available interaction resources in a platform-independent manner (Akoumianakis et al., 2000).

The Unified User Interface development paradigm is supported by a set of development tools, which have been built to provide an integrated framework that efficiently supports the design and implementation of Unified User Interfaces. The main characteristics of this framework are:

- Platform independence, intended to address the pluralism of interaction platforms and graphical environments (e.g., MS-Windows™, the X Windowing System), offering the versatility required for the management of different environments.
- Metaphor independence, so as to cater for the interaction needs and characteristics of diverse target user groups, which may necessitate the coupling of different interaction metaphors to different categories of users and usage situations.
- Automatic adaptation capabilities, so that the resulting user interfaces are adaptable and adaptive to the individual user abilities, requirements, skills and preferences.
- Unified interface specification, which aims to reduce the overall development costs for Unified User Interfaces through the introduction of specification-oriented (rather than implementation-oriented) interface construction techniques.

The Unified User Interface development platform provides a number of tools to facilitate the above novel objectives, including. a high-level language for User Interface specification (G-DISPEC, Savidis & Stephanidis, 1997), and a tool that automatically generates the implementation from such high-level specifications (I-GET, Savidis & Stephanidis, 1997; Stephanidis et al., 1997a, Savidis and Stephanidis, 2001c). Additionally, another tool has been developed, (PIM, Savidis et al., 1997a), which enables the generation of platform independent toolkits (i.e., programming libraries) for unified interface implementation. Two toolkits have been generated as examples of the viability of the approach: an augmented version of the Windows interaction object library, including scanning techniques (Savidis et al., 1997b); and, a toolkit for non-visual interaction (Savidis et al., 1997c). The adaptability of the User Interface to the specific needs, abilities, skills and preferences of the target user group is achieved at design time by means of a User Modelling Tool called USE-IT (Akoumianakis & Stephanidis 1997a; Akoumianakis & Stephanidis 1997b; Akoumianakis & Stephanidis 1999; Akoumianakis and Stephanidis 2001).

2.2 Early applications and demonstration phase

The unified user interface development method was validated in the context of the TIDE-ACCESS project in two application domains, namely:

- the development of a hypermedia application accessible by blind people (Petrie et al., 1997), and

- the development of two communication aid applications for the speech-motor and language-cognitive impaired users (Kouroupetroglou et al., 1996).

However, the major demonstration of the methodology was carried out in the context of the ACTS-AVANTI[2] collaborative research and development project. In the AVANTI project, the Unified Interface Development methodology was applied in the domain of the World Wide Web to provide adaptable and adaptive browsing technology for access to metropolitan information systems by users with diverse abilities, skills, requirements and preferences. The systems were targeted for the population at large, including people with disabilities. In particular, based on the Unified User Interface development methodology, a Web browser was designed and implemented to act as the front end of the information systems, and provide accessibility and high quality of interaction to able-bodied, blind and motor-impaired users (Stephanidis et al., 1998b; Stephanidis et al., 2001).

In all these efforts, there was a strong evaluation aspect, which provided informative feedback not only on the quality of the developed systems but also on the use and technical capabilities of the tools. Moreover, the experiences gained have indicated areas of potential improvement, as well as input needed from various disciplines and HCI communities. This aspect is further elaborated in the next section of this paper, where we examine future research directions and challenges.

2.3 Comparison with prevalent user interface development practices

The premise of Unified User Interface development is that of studying the global execution context of tasks and human activities, to identify suitable alternatives for accommodating individual requirements. This calls for analytical insight and pluralism in the respective outcomes, as no single solution is likely to be acceptable to all users. Such a focus contrasts the prevailing HCI design philosophy and supporting methodologies, which are primarily single-artefact oriented. It follows that Unified User Interfaces require a broader scope of design to explicitly account for context-oriented phenomena, as well as a powerful development framework to enable the generation of user interface implementations through specifying, rather than programming, interactive dialogues.

Such an approach necessitates a shift of perspective, in relation to current design and development practices. In particular, the design of Unified User Interfaces requires explicit means to account and model context-oriented parameters. However, such contextual insights can only be facilitated by adopting more suitable units for analysing and modelling interactions (e.g., activity), than contextually isolated user actions (or keystrokes) that have been the primary focus of cognitive models.

[2] The AVANTI AC042 (Adaptable and Adaptive Interaction in Multimedia Telecommunications Applications) project was partially funded by the ACTS Program of the European Commission, and lasted 36 months (September the 1st, 1995 to August the 31, 1998). The partners of the AVANTI consortium are: ALCATEL Italia, Siette division (Italy) - Prime Contractor; IROE-CNR (Italy); ICS-FORTH (Greece); GMD (Germany), VTT (Finland); University of Siena (Italy), MA Systems and Control (UK); ECG (Italy); MATHEMA (Italy); University of Linz (Austria); EUROGICIEL (France); TELECOM (Italy); TECO (Italy); ADR Study (Italy).

Additionally, the focus of design is on populating design spaces, rather than identifying a single best fit. Table 1 summarises some of the major differences between unified and traditional design practices.

Table 1: Contrasting traditional and Unified User Interface design

Design Aspect	Traditional development paradigm	Unified User Interface development
Focus	Single artifact that fits all	Analytical insights to populate design spaces
Outcome	Single object hierarchy	Polymorphic task hierarchy
Process	Top down or bottom up	Middle out
Scope of design representation	Implicitly bound to the object hierarchy	Bound to rationalized design spaces; explicit in the run-time behavior

Moreover, unified development requires corresponding means to provide the basis for user interface implementation. This challenges traditional practices with regards to both the architectural model according to which unified artefacts become embedded into user interface implementations, and the mechanisms offered for context-sensitive processing of alternatives towards the selection of a maximally preferred option. In Table 2, we contrast traditional and Unified User Interface development.

Table 2: Contrasting traditional and Unified User Interface development

Development Aspect	Traditional development paradigm	Unified User Interface development
Implementation model	Programming as the basis for generating the user interface implementation	Generation from specifications
Premise of run-time code	Making direct calls to a platform	Linking to the platform
Platform utilization	Multi-platform environments	Multiple toolkit environment
Platform independence	Generalization across platform properties	Platform abstraction mechanism

3. FROM USER INTERFACES FOR ALL TO AN INFORMATION SOCIETY FOR ALL

The experience described above provided valuable insight into the technical validity of the notion of *User Interfaces For All*, and at the same time it highlighted the numerous challenges involved in developing truly accessible and high quality interactive environments. In particular, while such a concept was introduced in order to cope with the HCI challenges of the emerging Information Society, additional research directions are necessary to address the wide spectrum of concerns pertaining to content and telecommunications infrastructure (see Figure 3). Efforts towards universal accessibility of the interactive components of Information Society Technologies have met wide appreciation by an increasing proportion of the international research community, thus leading to the foundation of working groups and scientific forums. Among them, the ERCIM working group on "User Interfaces for All" (Stephanidis, 1995b) aims at planning a path that, apart from meeting technical objectives, will bring closer researchers and teams working in the different ERCIM organisations (but also organisations beyond ERCIM or the European boundaries), who share common interests and aspirations, and would like to contribute to the endeavours towards making the emerging Information Society equally accessible to all.

Two other very recent initiatives are the forthcoming 1st Universal Conference on Universal Access in Human-Computer Interaction[3] and the Springer archival journal Universal Access in the Information Society[4]. These two initiatives in collaboration seek to provide the dissemination channels for documenting research results and appropriating the benefits of an increasing international momentum and interest on the topics of universal design and universal access. In the years to come, they are expected to contribute towards the establishment of a critical mass of knowledge that will raise awareness about, and create a culture for, universal access in the emerging Information Society.

3.1 The International Scientific Forum

The need for a global approach towards an Information Society for all was first recognised in 1997 by the International Scientific Forum "Towards an Information Society for All' (ISF). ISF was launched in 1997, as an international ad hoc group of experts sharing common visions and objectives, namely the advancement of the principles of universal access in the emerging Information Society.

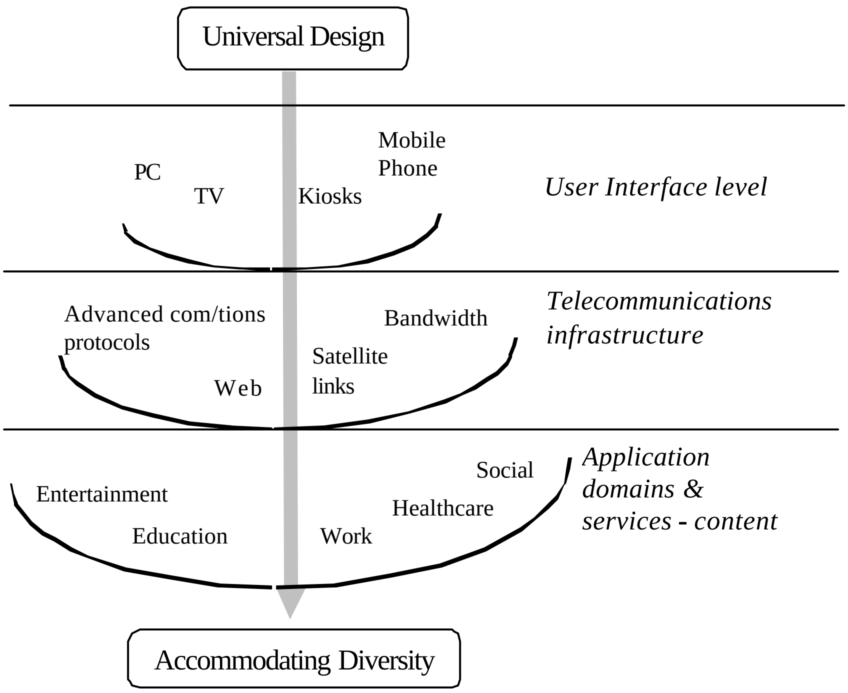

Figure 3: Levels of concerns and implications of design for all

[3] http://uachi.ics.forth.gr

The Forum held three workshops[5] to establish interdisciplinary discussion, a common vocabulary to facilitate exchange and dissemination of knowledge, and to promote international co-operation. The Forum has produced two White Papers (Stephanidis et al., 1998a; Stephanidis et al., 1999)[6]. The White Papers report on an evolving international R&D agenda focusing on the development of an Information Society acceptable to all citizens, based on the principles of universal design. The proposed agenda identifies technological and user-oriented issues, critical application domains, and required support measures. The Forum has also elaborated on the proposed agenda by identifying challenges in the field of human-computer interaction, and clusters of concrete recommendations for international collaborative R&D activities. Moreover, the Forum has addressed the concept of accessibility beyond the traditional fields of inquiry (e.g., assistive technologies, built environment, etc), in the context of selected mainstream Information Society Technologies, and important application domains with significant impact on society as a whole.

3.2 IS4ALL

Based on the success of its initial activities, the Forum has proposed to the European Commission the IS4ALL (Information Society for All) Thematic Network in the form of a Working Group, which has been accepted and will now run from 1st October 2000 to 30th September 2003. The aim of this Working Group is to advance the principles and practice of universal access towards the wider IST community. In particular, the project focuses on the area of Healthcare Telematics, a critical Information Society application domain, and on emerging technologies shaping the nature and contents of this domain. IS4ALL is therefore seeking to establish on a more formal basis a wider, interdisciplinary and closely collaborating "network of experts" (Working Group) to provide the European Healthcare industry with a comprehensive information package detailing how to appropriate the benefits of universal design. Specifically, IS4ALL is aiming to provide industry with appropriate instruments to approach, internalise and exploit the benefits of universal access, with particular emphasis on Health Telematics.

Toward this objective, IS4ALL will develop a comprehensive code of practice (e.g., enumeration of methods, process guidelines) consolidating existing knowledge on universal access in the context of Information Society Technologies, as well as concrete recommendations for emerging technologies (e.g., emerging desktop and mobile platforms), with particular emphasis on their deployment in Health Telematics. IS4ALL will also undertake a mix of outreach activities to promote universal access principles and practice, including workshops and seminars targeted to mainstream IT&T industry.

The specific technological / scientific objectives to be attained by IS4ALL can be summarised as follows:

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[4] http://link.springer.de/journals/uais/

[5] The 1st workshop took place in San Francisco, USA, August 29, 1997, and was sponsored by IBM. The 2nd took place in Crete, Greece, June 15-16, 1998 and the 3rd took place in Munich, Germany, August 22-23, 1999. The latter two events were partially funded by the European Commission.

[6] The white papers are also available on-line [http://www.ics.forth.gr/proj/at-hci/files/white_paper_1998.pdf] and [http://www.ics.forth.gr/proj/at-hci/files/white_paper_1999.pdf].

- Consolidate existing knowledge on universal access in the context of Information Society Technologies, which is currently dispersed across different international sites and actors, into a comprehensive code of design practice (e.g., enumeration of methods, process guidelines, etc).

- Translate the consolidated wisdom to concrete recommendations for emerging technologies (e.g., emerging desktop and mobile platforms) in a critical application domain, which is Healthcare Telematics.

- Demonstrate the validity and applicability of the recommendations in the context of concrete scenarios drawn from an experimental regional Healthcare Telematics network.

- Promote universal access principles and practice in Healthcare Telematics through a mix of outreach activities, including 6 seminars and participation in several international conferences.

IS4ALL is a multidisciplinary Working Group co-ordinated by ICS-FORTH. The other members include: Microsoft Healthcare Users Group Europe (MS-HUGe), the European Health Telematics Association (EHTEL), CNR-IROE, GMD, INRIA, and FhG-IAO. Working Group members bring together a diverse range of competencies, which are necessary for the aims and objectives of IS4ALL. Institutionally, the Working Group brings together:

- four research institutes with proven track record across a range of technological fields including, Healthcare Telematics, assistive technologies, Human Computer Interaction, universal access and technology management; and

- two consortia of Healthcare Telematics industry user groups, where most of the main industrial actors in the Healthcare Telematics in Europe participate; additionally, the co-ordinating contractor provides the link with HYGEIAnet, the Regional Healthcare Network of Crete.

In addition to the above, there will be several subcontractors who will be contacted in the course of the project and as the need arises.

4. CONCLUDING REMARKS

This paper has discussed the notion of a transition from R&D activities aiming towards *User Interfaces for All* to the broader context of activities towards an *Information Society for all*. We have defined *User Interfaces for All* as a systematic approach to the design, implementation and evaluation of user interfaces which cater for the requirements of the broadest possible user population. The scope of *User Interfaces for All*, as a perspective on HCI, is necessarily broad and complex, involving challenges that pertain to issues such as context-oriented design, diverse user requirements and adaptable and adaptive interactive behaviors. This complexity arises from the numerous dimensions that are involved, and the multiplicity of aspects in each dimension. Accordingly, the fields of science that might provide useful insights towards *User Interfaces for All* are many and diverse.

On the other hand, the notion of an Information Society for all is a broad concept, which embodies and extends the User interfaces for all research agenda to address new frontiers. To this end, a first step was the International Scientific Forum "Towards and Information Society for All", which is now followed-up by the new IS4ALL project, funded by the EC IST programme. IS4ALL brings together a multidisciplinary group of experts to form a Working Group, and seeks to provide the IST community with results that will advance and promote universal design thinking within IST in general and Healthcare Telematics in particular. While IS4ALL is just one measure, with set objectives, scope and deadlines, many more such activities will be needed to accomplish the visionary goal of an all-inclusive Information Society.

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