Children in the Information Society: addressing tomorrow's Unified Environments of Use

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Abstract. The technological evolution we are experiencing, as well as the increasing number and the diversified nature of human activities that are supported by computers, will soon lead to a new paradigm of computing, often referred to as Environments of Use. Children will have to live, learn, communicate, and coexist with these environments. This will progressively lead to the consideration of children as mainstream users of technology, rather than a niche market for interactive educational software and games, as the case is today. This position paper proposes a potential route to proactively meeting children's needs in this context, based on the theoretical and technical framework provided by Unified User Interfaces, and elaborates upon the vision of the Unified Environments of Use of tomorrow, focusing in particular on children as a target user group.

1. INTRODUCTION

In today's IT&T industry children represent an important target user group for many hardware and software companies which develop dedicated products. Increasingly sophisticated game and education titles, some of which combine physical objects (e.g., toys) with interactive software, appear in the market every so often. Interest is also arising in software that combines the entertainment and education dimensions in a genre termed 'edutainment'. Software for children, under this perspective, is disassociated from software for adults. For the latter, an expanding software industry develops networked productivity-enhancement tools oriented to the business use. More generally, applications and services targeted to adults address thematic domains, feature specialised content and functionality, and often have complex user interfaces, which render them of little interest, or entirely inappropriate, for children. Thus, children have traditionally constituted a significant niche market, but have seldom been seen as part of the 'mainstream'.

Although the separation between the two worlds is well established at the moment, it is argued that the borders will shift significantly in the coming years. The driving forces for this shift are manifold:

- The emerging Information Society will progressively manifest itself in all sectors of human activity, including work, leisure, education, etc. This will bring forward the requirement to smoothly integrate people in the technology-rich and community-centred infrastructure from an early age. Furthermore, the integration will have to happen on the children's own terms, i.e., in a way that does not require them to 'adapt' to the technological environment, but rather tailors the environment to their abilities, skills, requirements and preferences, and enables the environment to 'evolve' along with its young users.

- The application and thematic domains that different genres of software represent no longer entail exclusive use by particular categories of users. For example, the potential of distance learning has given rise to the concept of life-long learning, making education an activity that is not constrained to schooling, but rather spans an individual's lifetime, changing appropriately in scope and content with time. Conversely, computers find their way onto the children's desktop, not only as tools for learning, or game-machines, but also as companions for creative activity. In this context, their characteristics and requirements are similar to those holding for adults.
- Computing itself is in the process of changing dramatically. From a machine-embodied form, which has prevailed for several decades, it is now becoming embedded in our physical environment. Intelligent homes, car navigation and Web access systems, wearable computers, and sensors woven into clothes are some of the new developments that progressively embed computing power in the environment, and are expected to make it as ubiquitous, unobtrusive and universally accessible as electricity is today. This new environment will be inhabited by everyone and at anytime, making it necessary to ensure that it is appropriate for, and acceptable by, wildly differing categories of individuals, including children. Ubiquitous computing is already appearing in applications specifically designed for children, in particular toys such as programmable bricks (Resnick at al., 1999) and interactive dolls.

In view of this foregoing shift, this paper raises a number of issues relating to the inclusion of children in the concept of 'mainstream' user. This implies considering children not as a special niche market, but rather a significant (in terms of attention received) portion of the population being targeted by mainstream software industry. In particular, the paper outlines some of the characteristics of the 'environments of use' of the future, and discusses the role of children within them. Subsequently, it discusses how the needs of children can be addressed proactively in this context, so that they are not catered for through post-development adaptations, or ad-hoc dedicated developments such as those addressing people with special needs (Stephanidis and Emiliani, 1999). The paper then presents an example of how existing technologies and tools intended to facilitate the development of interactive software for *all* users, has resulted in a prototype Web browser that addresses the requirements of a diverse target population. Finally, the potential that such technologies offer to children as a target user group is discussed.

2. ENVIRONMENTS OF USE

The term "environments of use" has been introduced (Stephanidis et al., 1998) to refer to integrated systems sharable by communities of users. Environments of use (EoUs) transcend the traditional notion of computers as productivity tools, aiming to enable a richer set of interactions than is possible today, not only between human and machine, but also among humans. In contrast to tools, which enhance the productivity of individuals, EoUs are intended to promote the concept of loveable systems (Tamura, 1999), suitable for a broad range of communication and collaboration intensive activities amongst groups of people. Such environments should be characterised by sympathy and care for users and non-users[1] (Stephanidis et al., 1998) and should be accessible by anyone, anytime, anywhere. Finally, they should provide unobtrusive means for supporting social activities.

[1] The term is used to refer to individuals that, although not interacting with the computing environment, are affected by it directly or indirectly, as the latter is being used by others.

Along a different dimension, EoUs also signify the progressive integration of the computing environment with the physical environment (Stephanidis et al., 1998). The current embodiment of computers as machines that support a range of tasks for one user at a time (the same user employing their input and output devices) is not expected to prevail in the future. In fact, it is foreseen (Stephanidis et al., 1999) that computing power and interactivity will be "integrated" into our living environment in a way similar to electricity. Users and non-users alike would then need to actively and consciously coexist within, and share, such a living environment, employing interaction facilities different from those used today.

Against this background, it has been argued (Stephanidis et al., 1998) that EoUs are likely to become integral components of daily activities amongst communities of users and facilitate the establishment of new forms of social endeavours. Consequently, they should be conceived and designed as community-centred, sharable, expandable, co-operative, collaborative and responsive systems, catering through user and environment monitoring, for a broad range of human needs, for both users and non-users. Additionally, they should offer voluntary and context-specific user support, exhibit error tolerant behaviour, and provide preventive actions against unforeseen circumstances and / or misuse.

It follows from the above that EoUs constitute a major departure from human-computer interaction as we experience it today. Their distinctive characteristics outlined above, introduce numerous new possibilities in human-computer and human-human interaction. However, they also introduce challenges that should be treated proactively, so as to ensure that EoUs are inherently accessible and usable by the broadest possible end user population, as well as acceptable in terms of their integration into the evolving social and organisational systems.

In this context, children represent a particularly important portion of the population that will inhabit, coexist and interact with such EoUs. They will have the role of both users and non-users of technology, directly communicating and using the environment, or being affected by others' interactions, respectively. They will grow up, evolve, acquire knowledge and skills, through, as well as in parallel with, the environment. Moreover, they will use the EoUs as intermediaries in communication, collaboration, entertainment, and other activities that are of an inherently social nature. As a result, children will need to be enabled and facilitated to exploit, to the best of their abilities, the information facilities and artefacts that surround them. At the same time, they will need to be protected from potentially negative aspects of such an environment, similarly to the way they can, in principle, be protected today from inappropriate content on the Web.

To better depict the issues arising from the co-existence of children and adults in EoUs, consider the following imaginary setting. Assume that, in an EoU of the future, our communication and collaboration with other people is facilitated by a communication device that employs a large wall-mounted display and 3D sound for output, and a camera, speech recognition, and gestures on the touch-sensitive display for input. This very same device will have to be used by both adults and children. Apparently, the activities that the two categories of users perform with it, and the way in which they use it, can be very different. Even the simple task of initiating communication with particular peers would need to be approached in entirely distinct ways, taking into consideration the scope, purpose, duration and context that the activity has in each case. For example, the mother might need to place a call to her company's meeting room, in order to participate in a virtual meeting with colleagues. On the other hand, the child might want to talk with his two closest friends about something

interesting that happened on the way back from school, taking advantage of the opportunity to play a game with them.

An important topic stemming from the above scenario is that, from the perspective of children, EoUs should not be approached as intelligent and ubiquitous machines that can be employed in the solitary pursuit of goals (Fulton Suri, 1997). Rather, they should be designed following the same principles used for other physical objects and instruments that facilitate and augment the social, educational and other activities of children. For example, they should provide multi-sensory experiences, enable the formation and exploration of concepts, be open-ended (rather than defining "one best way" for tasks to be accomplished), and be friendly and forgiving. More importantly, they should strive to minimise the "distance" between children, including remotely located ones, making it possible for them to engage in social play, which constitutes a large part of their development (Fulton Suri, 1997).

It follows from the above that children will need to be fully empowered users of tomorrow's EoUs. This entails the *proactive* consideration of their needs, so that these can be adequately addressed while the new computing paradigm is still shaping. Unless children represent explicit design targets in the development of the new virtualities[2], they will be excluded from them, and will have to be catered for in a fashion similar to the one people with special needs are today. The question that naturally arises then, is how such proactive approaches can be achieved, and what scientific methods can be adopted as a basis for future developments. The next section introduces Unified User Interfaces as an appropriate framework for a proactive approach to the development of user interfaces that cater for children's characteristics, requirements and preferences.

3. DESIGN FOR ALL AND UNIFIED USER INTERFACES

The term *design for all* is frequently associated with different connotations (Story, 1998). In this paper, the term is used to reflect a new concept, or philosophy for Human Computer Interaction (HCI) design that recognises, respects, values and attempts to accommodate the broadest possible range of human abilities, requirements and preferences in the design of all computer-based products and environments (see also Stephanidis et al., 1998). Thus, it promotes a design perspective that eliminates the need for "special features" and fosters individualisation and end-user acceptability of IT&T products. This does not imply a single design solution suitable for all users. Instead, it should be interpreted as an effort to design products and services, in such a way so as to suit the broadest possible end user population. In doing this, it is more than likely that there will be different solutions for different contexts of use. The concept of *design for all* should be clearly differentiated from the more traditional approach involving the *a posteriori* adaptation of interactive software to build accessibility features, as a result of specific user requirements (reactive approach). In contrast, *design for all* in HCI fosters a pro-active strategy postulating that accessibility and quality of interaction need to be embedded into a product at design time, as opposed to being considered as an afterthought.

The concept of *User Interfaces for All* (Stephanidis, 2000a) applies, exemplifies and specifies the principles of *Universal Access* and *design for all* in the context of HCI. Proactive strategies entail a purposeful effort to build access features into a product, as early as possible

[2] The term *virtuality* is borrowed from (Winograd, 1996) where it is defined as "… the world in which a user of the software perceives, acts, and responds to experiences".

(e.g., from its conception, to design and release). In the context of HCI, *User Interfaces for All* advocates such a proactive paradigm for the development of user interfaces accommodating the broadest possible end-user population (Stephanidis, 1995). In other words, the concept of *User Interfaces for All* seeks to minimise the need for a posteriori adaptations and deliver products that can be adapted for use by the widest possible end-user population. This implies the provision of alternative interface manifestations depending on the abilities, requirements and preferences of the target user groups.

The EC-funded TIDE TP1001 ACCESS project (see Acknowledgements), 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, 2000b), and delivered a novel user interface development platform (Akoumianakis & Stephanidis 2000; Savidis et al. 2000, Savidis & Stephanidis, 2000) This development environment comprises methodologies and tools for the construction of user interfaces which are platform- and user-profile independent, and can be adapted to the individual end user characteristics (Stephanidis and Emiliani, 1999).

The *Unified User Interface Development Methodology* was demonstrated in the context of the ACCESS project in specific applications targeted to disabled users. Subsequently, it was applied by the ACTS AC042 AVANTI project (see Acknowledgements) in the development of a unified Web browser inherently accessible by different categories of users (Stephanidis et al., 2000). The AVANTI Web browser (acting as a front-end to the AVANTI Web-based information systems) aims to provide *accessibility* and *high quality interaction* to *all* potential users. Towards this end, and following the Unified User Interface Design methodology, the prototype browser addresses the different abilities and skills, and diverse requirements and preferences of a wide range of users, including disabled and elderly people. Lexical and syntactic self-adaptation techniques are applied, in order to provide accessibility and high quality interaction to different categories of users.

Two instances of the user interface of the AVANTI browser are depicted in Figure 1 and Figure 2 below. These instances exemplify the self-adaptation capabilities of the browser and present: (a) an instance of the interface intended for use by able-bodied, experienced computer users, knowledgeable of the Web and the functionality it supports (Figure 1), and (b) an instance of the interface intended for use by novice computer users, with little knowledge of, and experience in, the Web (Figure 2). Some of the adaptation techniques that can be observed in the examples, and that might also prove useful for children, include: 'hiding' application functionality to improve simplicity (e.g., the menus have been removed in the second instance); providing alternative / additional cues to convey the interactive qualities of artefacts (e.g., links presented as buttons in the second instance); replacing interactive facilities with ones that are less 'standardised' but provide better affordances to inexperienced users (e.g., replacing scrollbars with 'scroll-buttons'), etc.

The novel concept of Unified User Interfaces has signified a departure from the traditional premises of Human-computer Interaction, by first claiming, and then proving, the practical feasibility of designing and developing for a very wide and differing spectrum of users. It is argued that the same underlying principles of "unification", accompanied by a new generation of design-, implementation- and evaluation- support methods, techniques and

tools, can be used for the development of Unified EoUs that cater for the needs of *all* users, including children (Stephanidis et al., 1998).

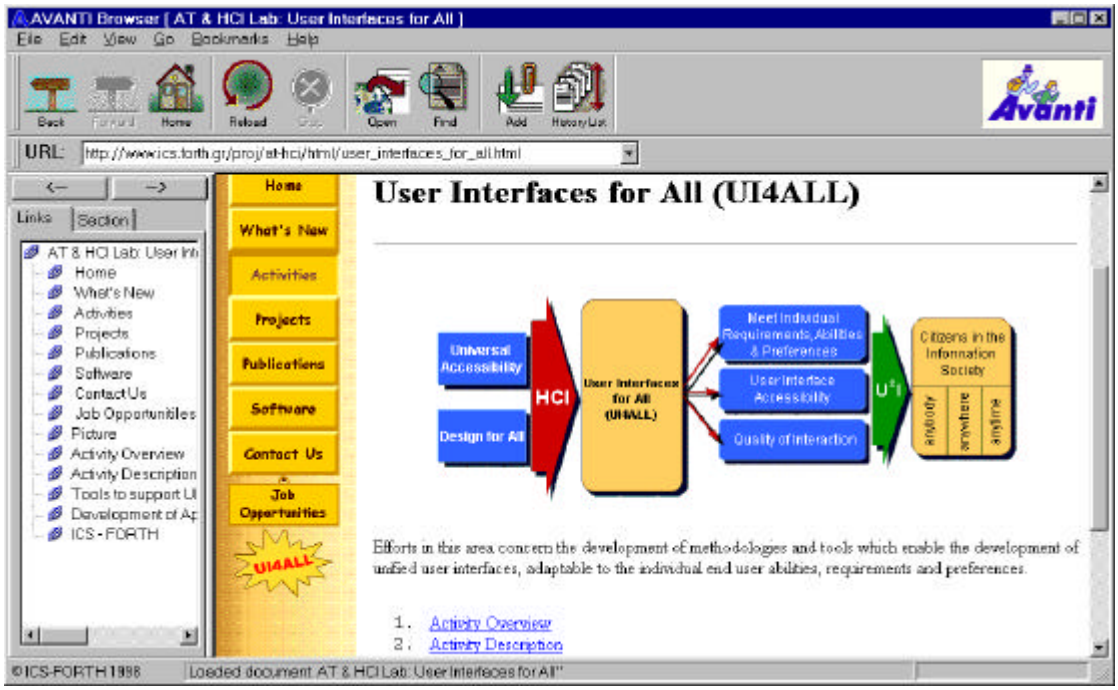

Figure 1: Typical instance of the AVANTI browser.

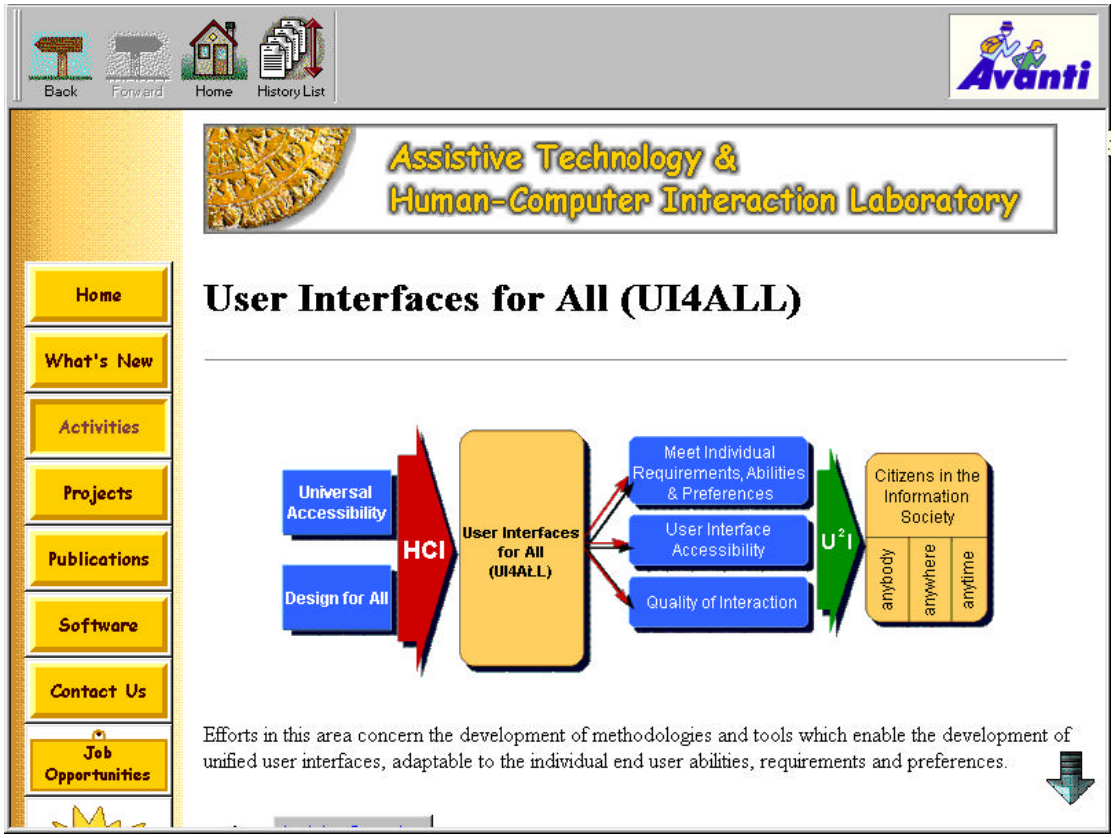

Figure 2: The browser's interface has been adapted for use at public information kiosks.

From the perspective of Unified Environments of Use, children constitute a population with "special needs", abilities and skills. Indeed, they are not very different from adults that require simplified interaction facilities, and extensive assistance and feedback in order to complete tasks; or, from individuals that don't have full use of their motor abilities, and therefore cannot perform fine-detailed operations with the mouse; or, from people that, due to lack of education, or to physical or circumstantial disadvantages, cannot attain information conveyed in textual form[3]. At the same time, it needs to be stressed that children should not be treated as "adults-in-waiting" (Druin, 1997), i.e., they should not be viewed as "constrained" versions of adults, with limited skills and cognitive or motor capabilities, but rather as individuals that have their own beliefs and behavioural patterns, and their characteristic needs, all of which change at very fast paces (Oosterholt, Kusano, and de Vries, 1996). It is, therefore, argued that, by addressing the needs of the younger generation (and by doing so in a way that respects and values individuality and age-related knowledge, abilities and preferences), *all* users of interactive environments will benefit from the increased accessibility and quality in use that will come as a result.

Accessibility, in this context, is not bound to the narrow interpretation of facilitating people to engage in communication with an interactive system through adaptations. Rather, accessibility is viewed from the perspective of *universal access*, which entails more than *direct access* or access through *add-on (assistive) technologies* (Vanderheiden, 1990), since it emphasises the principle that accessibility should be a design concern, as opposed to an afterthought. Quality in use, on the other hand, goes beyond the established notion of what is the high level design objective for a system to meet the real world needs of its intended users (Bevan & Azuma 1997; ISO/IEC 14598-1, 1998), and entails the consideration of a broad range of functional and non-functional attributes, which characterise the use of information artefacts by humans, in their problem-solving, information seeking and communication-intensive computer-mediated activities.

These two complementary goals (i.e., accessibility and quality in use) are addressed, respectively, by the two dimensions of adaptation capability that unification entails: adaptability and adaptivity. If tomorrow's EoUs are provided with adaptability capabilities, children will be able to experience the surrounding computing and information infrastructure in a way that best suits their particular requirements and preferences. Furthermore, adaptivity can be employed to ensure that the environment is not static, but rather changes and evolves along with the child, automatically modifying itself to address both short-term and long-term changes that occur.

4. DISCUSSION AND CONCLUSION

This paper has argued that, in order to ensure that children will be fully empowered users of tomorrow's Environments of Use, forthcoming developments should follow a proactive approach to catering for children's needs. Furthermore, it has asserted that Unified User Interfaces can provide a theoretical and technical framework supporting and facilitating such a proactive approach. The rest of this section examines more closely the premises of these propositions.

Firstly, let us review the stated need for the adoption of proactive approaches in addressing the requirements of children as 'mainstream' users of EoUs. The underlying rationale is

[3] For some design guidelines for children software see, for example, Hanna et al. 1999.

founded on a parallelism between children as 'involuntary' users of tomorrow's technology and disabled users of today. This parallelism, which has also been introduced implicitly elsewhere in this paper, by no means suggests that children are to be viewed as 'yet another special population'. Rather, it seeks to emphasise the fact that, like disabled people, children will *have* to live in a technological environment, with (or through) which they will need to communicate and interact. Failure to support their effective, efficient, enjoyable and, ultimately, acceptable integration, will inadvertently result in their practical exclusion from that environment. Inability to access the surrounding technological environment, as well as its consequences (e.g., indirect exclusion from work-, social-, and other sectors of human activity), are evident in the case of disabled people and have led to a number of *reactive* approaches which currently prevail in the market (Stephanidis and Emiliani, 1999). However, none of these approaches have succeeded in ensuring unencumbered access, as the task they undertook is practically impossible to achieve: render interactive systems accessible by individuals whose requirements have not been taken into consideration during design and development (Stephanidis and Emiliani, 1999). This fact points to the necessity of accounting for the characteristics and requirements of *all* potential user categories of interactive systems from the very start of any design endeavour aiming to achieve true inclusiveness.

Another important dimension, in the case of children, is that the accessibility of EoUs is particularly relevant from an educational point of view. Through the use of appropriate interactive applications and services, tailored to their specific needs, children can get accustomed to technology, learn to use it effectively, and acquire access to invaluable information resources necessary for their successful integration in the Information Society. Towards this end, it is necessary that EoUs are designed in such away as to be both accessible and usable by children with different cultural backgrounds in different stages of mental, psychological and social development.

Unified User Interfaces constitute a promising approach along these lines, for two main reasons. Firstly, the very concept of unification, i.e., of a single interactive framework that incorporates alternative and complementary interactive artefacts, matches one of the primary characteristics of EoUs, namely their ubiquity and seamless integration with the physical environment that surrounds us, resulting in a single, comprehensive embodiment of computing power and interactivity. The single embodiment makes it necessary to integrate all the different (and possibly diverse) elements into one comprising whole, and make them selectively available as required; something, which is the cornerstone of the concept of UUIs. Secondly, the Unified User Interface Design Method (UUIDM) is based on the proactive consideration of the characteristics exhibited by all the target user categories and contexts of use, as well as on the explicit identification and representation of the suitable design alternatives into polymorphic task hierarchies (Savidis et al., 2000). In fact, UUIDM not only satisfies the proactiveness criterion posed earlier, but has been specifically developed to cater for it.

In addition to the above, UUIs can be exploited from both a theoretic and a technical perspective. Specifically, UUIs are accompanied, as already mentioned, by well-founded methods and techniques that span the entire development life cycle of user interfaces to interactive applications and services. Additionally, the implementation of UUIs is facilitated by a tool environment, which enables and supports the practical application of the related techniques in actual software development (Stephanidis, Savidis and Akoumianakis, 1997; Savidis and Stephanidis, 2000; Akoumianakis and Stephanidis, 2000). The new dimensions introduced by EoUs, in terms of technologies employed, but also in terms of the enhanced set

of human activity they affect, or are affected by, will contribute to updating the assumptions underlying UUIs. The same is true as far as the particular requirements of children are concerned and the way in which they affect traditional interaction software development (e.g., new activities, such as story-boarding, may need to be introduced in the design phase[4]). However, the clear disassociation of UUIs from particular technological platforms, interaction media / modalities / devices, and particular user groups, renders the current body of knowledge and experiences a sound basis for this evolution.

The realisation of the aforementioned convergence between the worlds of UUIs and interactive software for children would necessarily draw upon the complementary expertise and consolidated knowledge in the respective fields. Specifically, developing interactive artefacts whose unified user interface can cater for the particular needs of children, would bring together, on the one hand, specialised methods and techniques specifically intended for the development life-cycle of software for children (ranging from participatory design with children to children-based evaluation), and, on the other hand, the well defined methodologies and tools of UUI development. UUI design, for instance, specifies a structured approach to populating polymorphic design spaces (Savidis, Akoumianakis and Stephanidis, 2000); the theoretical and practical knowledge required to decide upon and rationalise the design alternatives, however, needs to be guided by processes that make it possible to obtain such knowledge from, through, or in co-operation with, the target end users (in the specific case, children). It is the authors' belief that the corpus of knowledge that is available today in each of the communities suffices to make the first steps towards the preliminary introduction of children as a target user group of unified interfaces. This would, in turn, enable the exploration of further concepts towards the establishment of Unified Environments of Use that have been *designed* to be used by children and adults alike.

In conclusion, this position paper has argued that in the context of the EoUs, children will inevitably become 'mainstream' users of computer technology. In order to cater for their particular needs in this respect, but also in order to make the best possible use of their qualities and skills, new, proactive approaches should be employed for the development of interactive software, which take these parameters fully into account, and relate them to the technological, social and environmental circumstances that collectively constitute the space of different contexts of use. Design for All and its embodiment in the concepts and tools supporting Unified User Interface development have been proposed as an appropriate initial source for theoretical and practical input in this direction.

ACKNOWLEDGEMENTS

The development of the Unified User Interfaces approach has been supported through collaborative research and development projects partially funded by the European Commission. These projects are:

The TIDE-ACCESS TP1001 project (Development Platform for Unified Access to Enabling Environments) of the European Commission (DG XIII). The ACCESS consortium comprised the following organizations: CNR-IROE (Italy) - Prime contractor; ICS-FORTH (Greece); University of Hertforshire (UK); University of Athens (Greece); NAWH (Finland); VTT

[4] See, for example, (Scaife and Rogers, 1999) for design techniques suitable for involving children in the design process.

(Finland); Hereward College (UK); RNIB (United Kingdom); Seleco (Italy); MA Systems and Control (UK); PIKOMED (Finland);

The ACTS-AVANTI AC042 project (Adaptable and Adaptive Interaction in Multimedia Telecommunications Applications) of the European Commission (DG XIII). 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).

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