Grand Challenges Conference Application

A Grand Challenge: Creating User-Centered, Usable, Ubiquitous Computing Environments

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A number of university, industry, and government research labs currently have research projects involving ubiquitous computing environments (http://endeavour.cs.berkeley.edu/; http://www-2.cs.cmu.edu/~aura/; http://oxygen.lcs.mit.edu/; http://portolano.cs.washington.edu/; http://www.intel.com/research/index.htm; http://www.cc.gatech.edu/projects/infosphere; http://www.cooltown.hp.com/cooltownhome/index.asp; http://www-3.ibm.com/pvc/index.shtml; http://www.itl.nist.gov/iad/highlights/Pervasive/). It is clear that ubiquitous or pervasive computing is the next computing paradigm. Weiser envisioned computation as becoming an integral part of the environment – so integral that it disappeared into the environment (M. Weiser, "The Computer for the 21st Century," Scientific American 265, No. 3, 94-104, September 1991). The grand challenge is to develop ubiquitous computing that is user-centered and usable so that it does disappear into the environment.

Bill Mark laid out three issues with pervasive computing: "When computation becomes part of the environment, most human-computer interaction will be implicit, and it will have to take account of physical space. Physical space rarely matters in current human-computer interaction; but as computational devices become part of furniture, walls, and clothing, physical space becomes a necessary consideration. First, more than one person can occupy a space. Second, individuals within the space are doing things other than interacting with the computer: coming and going, and perhaps most strikingly, interacting with each other--not just with the computer. Finally, physical space provides a sense of place: individuals associate places with events and recurrent activities" (Turning Pervasive Computing into Mediated Spaces, 1999, http://www.research.ibm.com/journal/sj/384/mark.html).

In order to produce ubiquitous or pervasive computing environments in which individuals are able to interact efficiently, effectively, and with a high degree of user satisfaction, we must first identify the human-environment interaction issues. Then we must produce methodologies for user-centered design and evaluation of ubiquitous computing environments. We have learned from the current desktop computing paradigm that technological solutions alone are not sufficient for producing systems that truly work for people. The CHI community has produced a number of user-centered design methodologies and usability techniques for designing and evaluating desktop systems. The community is now evolving these methodologies to use in designing and evaluating mobile systems such as mobile phones, PDAs, and mobile web access devices (Brown, B., Sellen, A., & O'Hara, K., 2000, A Diary Study of information Capture in Working Life, Proceedings of CHI 2000, 438-445) and for designing and evaluating web sites. (Ivory,

M. and Hearst, M., The State of the Art in Automated Usability Evaluation of User Interfaces, to appear in ACM Computing Surveys, 2002). The problem is that user-centered design and evaluation methodologies typically lag technology. The shift to a ubiquitous paradigm will pose many challenges. Ubiquitous computing is a disruptive technology – it will be extremely cumbersome to shift our living and work habits to this new paradigm without creating undue user overhead. Studies of collaboration systems have shown that a critical mass of users and information must be using the system and that it must be integrated with other systems in the workflow to be a serious candidate for use (Markus, M. L. (1987): Toward a `Critical Mass' Theory of Interactive Media. *Communication Research*, 14,5, 491-511). Therefore, it seems that it is imperative for the early systems to be as usable as possible or the uptake and adoption of ubiquitous computing environments will be seriously jeopardized or at best considerably lengthened. This necessitates the early development of user-centered design and evaluation methodologies for ubiquitous computing.

What are some of the issues in development of user-centered design and evaluation methodologies that will have to be addressed? First, there is the issue of requirement analysis. Technologies such as contextual inquiry are useful in our current environment to determine the problems users currently encounter in their tasks. While we can use some information from contextual analysis, this is likely to result in incremental improvements. We are looking for requirements for a completely different paradigm. Can we use simulations and virtual worlds to mock up environments that users can explore? What are other ways to help users to think outside of the box to gather initial user-requirements?

As Mark stated in the earlier quote, many of the user's interactions will be implicit. The environment will recognize some condition and some action will occur because of that. Given a slightly different interaction, a slightly different action may occur. How can these context-aware implicit interactions be tested? They must be tested for accuracy – do they really do what the developer intended? And they must be tested empirically. Does this action surprise the user or is it so natural that it truly disappears into the environment? Interfaces will be invisible for the most part. How will users determine what actions on their part cause actions or reactions on the part of the system? What do I say to a smart room? If nothing happens, what do I do? How can models of use be provided to users? Should I limit what a physical object can do based on what the physical form suggests?

Ubiquitous computing environments will be multi-person – a number of people interacting in the space at a given time, whether the space is my home, my office, the highway, or the supermarket. The resultant actions are a combination of the various actions or context created by the group of people present at any one time, their preferences, and their interactions. To evaluate the interactions and the corresponding system action, it is necessary to capture and analyze the individual interactions, information about the physical space and the relationships of people and space. Capturing this amount of information and being able to analyze it at a fine enough granularity to be informative in iterative designs is indeed a challenge. Given that many instances of use will be with geographical distributed groups the challenge becomes even greater.

Software testing in our current paradigm is sometimes carried out before the hardware is available. This has proven difficult for testing. Often testing has been broken into non-

functional device testing using a prototype and software functional testing on a legacy platform (Scholtz, J., Salvador, T., Lockhart, P., Newbery, J., 1997, Design: No Job too Small, Proceedings of CHI 97, 447-454). Having mockups or prototypes of devices for testing in a mobile situation is essential. We need to devise ways to mock-up devices quickly that can provide information about how the physical form influences the use of the device.

Edwards and Grinter (Edwards, W. & Grinter, R., 2001, At Home with Ubiquitous Computing: Seven Challenges, in Proceedings Ubicomp2001: Ubiquitous Computing, 256-272) define seven challenges for ubiquitous computing environments in the home. They state that they "hope to raise the awareness of the existing literature on the adoption, use, and history of domestic technologies, as well as the use of situated studies, and the benefits that these can bring to bear on the design and evaluation of technologies for the home." One challenge is designing for domestic use. Edwards and Grinter point out that ubiquitous computing will be disruptive to the home environment and designers must pay attention to a family's current home routines and study how new technologies are adapted into the home environment.

We tend to view user-centered design and evaluation as orthogonal to technological research. To achieve user-centered, usable, ubiquitous computing environments, we must give first-class status to user-centered design and evaluation methodologies. There are many research issues within this category including:

- Methods for doing requirements analysis
- User-centered evaluation of implicit interactions
- Evaluation of multi-person environments
- Capture and analysis of ubiquitous environments
- Prototyping environments for hardware devices
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Research in user-centered design and evaluation methodologies for ubiquitous computing must precede the deployment of ubiquitous computing environments to facilitate smooth and efficient transition to a new computing paradigm.

Bio:

Dr. Jean Scholtz is currently a computer science researcher in the Information Technology Laboratory at the National Institute of Standards and Technology (NIST). She works in the Information Access Division where her research interests are the evaluation of interactive systems. Her projects at NIST include:

- Human-robot Interaction
- Remote, automated evaluation methodologies for Web sites
- Evaluation methodologies for collaborative systems

Dr. Scholtz was the co-organizer of the NIST Industry USability Reporting Project, along with Dr. Keith Butler, Boeing. The goal of this project was to quantify usability so that it could be used as a factor in software procurement. This project developed the Common Industry Format (CIF) for reporting summative usability results. This has just become an ANSI/NCITS standard (354-2001).

From 1998-2001 Dr. Scholtz was on loan to the Defense Advanced Projects Research Agency where she was a program manager in the Information Technology Office. She managed the Intelligent Collaboration and Visualization program, the Information Management Program and the Ubiquitous Computing efforts at DARPA. She also started a seedling effort in Human-Robot Interaction, Synergistic Cyber Forces.

Prior to working at NIST, Dr. Scholtz worked at Intel Corporation where she was responsible for usability efforts both in the research divisions and in the development areas. She was co-manager of the human factors group developing desktop video products. Efforts by Dr. Scholtz and her group in engineering ethnography led to the creation of a new group at Intel.

Dr. Scholtz was a member of the Computer Science Faculty at Portland State University after receiving her Ph.D. in Computer Science from the University of Nebraska in 1989.

In her first life, Dr. Scholtz worked at Bell Laboratories in the Compiler Research Division where she was a member of the MULTICS group.

She is a member of the ACM, SIGCHI, and IEEE organizations. She is on the editorial boards of *Empirical Software Engineering* and *Interacting with Computers*. She was the Vice Chair of Finance for the SIGCHI EC from 1996-2000. She was a founding member of two local CHI SIGS – CHI FOO in Portland, Oregon (1989) and DC_CHI (1997) in the Washington, DC metropolitan area. She has held many positions in the CHI Conferences over the years. She is currently the co-chair of the HCI & IM Interagency Working Group on Information Technology R&D (a government working group created during the Clinton administration).

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