The Disappearing Computer

EU-NSF advanced joint research workshop
24. April 2004, Hotel Bristol, Vienna

Agenda

9:00 - 9:15 Welcome by the organizers and funding representatives, organisational issues

9:15 - 10:30 Session 1: Overview and introductions: Part I

9:15 - 9:40 Norbert Streitz (Fraunhofer IPSI)
The Disappearing Computer (DC) EU-FET initiative
(15 min presentation + 10 min. discussion)

9:40 - 10:00 Paddy Nixon (Strathclyde University)
Creating and Moulding Ambience:
Proposal for a new EU-FET initiative
(10 min presentation + 10 min. discussion)

10:00 - 10:25 Hans Gellersen (Lancaster University)
The EQUATOR programme in the UK
(15 min presentation + 10 min. discussion)

10:30 - 11:00 Morning Break

11:00 - 13:00 Session 2: Overview and introductions: part II

11:00 - 11:30 Anatole Gershman (Accenture)
Applications Perspective on Ubiquitous Computing
(15 min presentation + 15 min. discussion)

11:30 - 12:00 James Landay (Intel)
Proactive Computing at Intel Research Labs
(15 min presentation + 15 min. discussion)

12:00 - 12:30 Terry Winograd (Stanford University)
Relating theory and practice in ubiquitous computing
(15 min presentation + 15 min. discussion)

12:30 - 13:00 General Discussion and identification
of topical clusters for the afternoon

13:00 - 14:00 Lunch

14:00 - 15:30 Session 3: Discussion on selected topics in subgroups

15:30 - 16:00 Afternoon break

16:00 - 18:00 Session 4: Continuation of discussion, reports from subgroups in plenary, conclusions and next steps

18:00 End of Workshop
20:00 Dinner in Restaurant

Attendees

Representatives from funding organizations

Thomas Skordas	EC–FET, Brussels, Belgium	Thomas.Skordas@cec.eu.int
Panagiotis Tsarchopoulos	EC, Brussels, Belgium	Panagiotis.Tsarchopoulos@cec.eu.int
Remi Ronchaud	ERCIM, Sophia Antipolis, France	Remi.Ronchaud@ercim.org

Organizers

Norbert Streitz	Fraunhofer IPSI, Darmstadt, Germany	streitz@ipsi.fraunhofer.de
Paddy Nixon	University of Strathclyde, UK	Paddy.Nixon@cis.strath.ac.uk

EU Participants

Liam Bannon	University of Limerick, Ireland	liam.bannon@ul.ie
Joelle Coutaz	CLIPS-IMAG, Grenoble, France	Joelle.Coutaz@imag.fr
Hans Gellersen	Lancaster University, UK	hwg@comp.lancs.ac.uk
Achilles Kameas	CTI, Patras, Greece	kameas@cti.gr
Morten Kyng	University of Aarhus, Denmark	mkyng@daimi.au.dk
Spyros Lalis	University of Thessaly, Greece	lalis@ics.forth.gr
Allan Maclean	Image Semantics, Cambridge, UK	Allan.Maclean@imagesemantics.com
Friedemann Mattern	ETH Zürich, Switzerland	mattern@inf.ethz.ch

US Participants

Gaetano Borriello	University of Washington, Seattle	gaetano@cs.washington.edu
Roy Campbell	University of Illinois at Urbana-Champaign	roy@cs.uiuc.edu
Anind Dey	Intel Research Lab, Berkeley	anind@intel-research.net
Anatole Gershman	Accenture Technology Labs, Chicago	anatole.v.gershman@accenture.com
James Landay	Intel Research Lab, Seattle, & University of Washington	james.a.landay@intel.com
Joseph Paradiso	MIT Media Lab, Cambridge	joep@media.mit.edu
Daniel Russell	IBM Almaden Research Center, San Jose	daniel2@us.ibm.com
Terry Winograd	Stanford University	winograd@cs.stanford.edu

Abstracts and Curriculum Vitae of Attendees
(in alphabetical order)

Liam J. Bannon

Director of Interaction Design Centre
Dept. of Computer Science & Information Systems
University of Limerick, Ireland
www.idc.ul.ie

e-mail: liam.bannon@ul.ie
Tel: +353-61-20-2632/2699
Fax: +353-61-20-2734

Short CV
Liam Bannon is a Professor in the Department of Computer Science and Information Systems and founder Director of the Interaction Design Centre at the University of Limerick. His research interests range over the gamut of human-technology relations, including cognitive ergonomics, human-computer interaction, computer-supported cooperative work, computer-supported collaborative learning, new media and interaction design, and social dimensions of new technologies. He was a founding editor of *CSCW: The Journal of Collaborative Computing* and is on the editorial boards of*; Journal of Cognition, Technology, and Work*; *Requirements Engineering Journal, Universal Access in the Information Society Journal*; *International Journal of Cognitive Technology*, and the forthcoming *Co-Design Journal*. He was formerly on the editorial boards of *Behaviour and Information Technology Journal, and Journal of Computer Assisted Learning*. Recent research funding include EU FET DC SHAPE & Sob projects, and Science Foundation Ireland Shared Worlds project.

Key words
human-centred computing, interaction design, socio-cultural theory, place, human experience

Abstract
Even as we develop ground-breaking technologies within a ubiquitous computing paradigm, and open up new design spaces involving the meshing of physical and computational objects and media, we come up against the perennial problem of understanding people’s lifeworlds and the nature of human, social and cultural life – within which our technologies must operate. I believe we need a rich understanding of the human, social and cultural world in order to design technological artefacts and environments that people find useful and usable, as well as engaging and playful. There is a need for interdisciplinary research in a number of areas and at a number of levels to explore the possibilities of technical advances in specific domains, as well as investigating new paradigms for how people can interact with and through the new technologies. I believe that there is a felt need, both in Ireland, the EU, and at a global level, for new ideas, concepts and demonstrations concerning how to think about, develop, and trial for human use, the new technological innovations. A key feature of these developments is the increased possibilities for interaction between people with and through the media with which they are engaged. We need to consider the relation between technology and the individual, the community, and the environment. As we enter a new century, issues of sustainability, aesthetics and quality of life all need to be integrated into our research on technological developments. It is this emphasis on human concerns and activity in relation to technology development and use that characterizes a perspective I label “human-centred” interaction design.. This approach builds on a variety of human and social science traditions that focus on understanding human activity, all of which seek to provide useful and pertinent observations on human action in the world. Novel technologies may play an important role in these human activities, but more likely as a mediating influence, rather than as a conversational partner. I believe that we should learn from the failures of certain kinds of pro-active, technology-push, applications. People do not want to be inundated with “information”. Their needs change depending on the situation they are in, so it is difficult to satisfy their needs simply by means of personal profiles or adaptive systems. Again, playing devil’s advocate, I would strongly urge that developers explore design spaces that do not necessarily assume advances in machine intelligence, nor more detailed user models. Computers can work on behavioural data, and reflect this back to people, without needing to “interpret” its meaning. The relevance of this approach to technology development is that it provides a distinct perspective that encompasses many of the key issues being faced by (ubiquitous) technology designers today – issues such as awareness, context, interaction, engagement, emotion.

Gaetano Borriello

University of Washington
Dept. of Computer Science & Engineering Campus
Box 352350, Seattle, WA 98195, USA
www.cs.washington.edu/homes/gaetano

e-mail: gaetano@cs.washington.edu
Tel: +1.206.685.9432
Fax: +1.206.543.2969

Short CV

Gaetano Borriello is a professor of computer science and engineering at the University of Washington. His research interests are in ubiquitous computing and principally in new hardware devices that integrate seamlessly into the user's environment with particular focus on location and identification systems. He was the founding director of the Intel Research Seattle laboratory from 2001 to 2003. He served on the committee that wrote the National Research Council's recent report "Embedded, Everywhere" outlining a research agenda for embedded sensor networks. Currently, he serves on the editorial board of IEEE Pervasive Computing Magazine and the program committees for the conferences on Mobile Systems, Applications, and Services (Mobisys), Ubiquitous Computing (Ubicomp), and Embedded Networked Sensor Systems (Sensys).

Key words
ubiquitous and pervasive computing, location-aware computing, personal-area networks, sensors and sensor networks, tangible user interfaces.

Abstract

Location-awareness is a critical component of ubiquitous computing systems. We are focusing our research on two aspects of this problem: location estimation, and wide-area mass-scale deployment

We argue for the use of probabilistic methods to perform location estimation. We can demonstrate that these methods can be accurate, flexible, and practical. Probabilistic methods provide the same or better accuracy as deterministic approaches while being inherently more flexible in two important ways: the ability to fuse data from different sensor types and the ability to present a more valuable interface to applications by providing a probability distribution of the estimate. Moreover, it is practical to run such algorithms on devices ranging from high-end servers to handhelds and consider the computational requirements as well as memory footprint. Based on these analyses and on the successful research, commercial, and community adoption of our approach, we conclude that probabilistic methods enjoy many advantages that make them the best choice for a wide variety of mobile and ubiquitous computing systems.

To be widely adopted, location-aware computing must be as effortless, familiar and rewarding as web search tools like Google. We envisage the global scale Place Lab, consisting of an open software base and a community building activity as a way to bootstrap the broad adoption of location-aware computing. The concept seeks to take advantage of the exponential increase in deployment of wireless access points. We use these APs as beacons that index a database through their MAC addresses. This permits a privacy-friendly client-side computation of location similar to GPS. Early results show tracking in urban areas can be as accurate as 30m without even taking signal-strength into account. We are currently working on methods to also position users on floors of buildings in addition to 2-D coordinates. Further research is ongoing in how to determine “places” from positions and provide higher-level semantically-rich abstractions of locations to users and applications.

Roy H. Campbell

Siebel Center of Computer Science,
University of Illinois at Urbana-Champaign,
201 N. Goodwin Avenue MC-258, Urbana, IL 61801-2302, USA
http://cs.uiuc.edu/~rhc

e-mail: rhc@uiuc.edu
Tel: +1-217-333-0215
Fax: +1-217-244-6869

Short CV
Dr. Campbell received his Ph.D. Degree in Computer Science from the University of Newcastle upon Tyne in 1976. He is a professor of computer science and has supervised the completion of thirty one Ph.D. dissertations, over one hundred M.S. theses and is the author of over one hundred and seventy research papers on security, programming languages, software engineering, operating systems, distributed systems, and networking. His current research interests include the context awareness, security, privacy, networking and infrastructure concerns of ubiquitous computing and active space environments.

Key words
context and location awareness, mobility, security and privacy, ubiquitous applications

Abstract
I believe in a future where people’s living spaces are interactive and programmable. Users interact with ubiquitous applications as they move from space to space, taking applications with them, accessing space specific applications, and building new applications interactively as needed. Users interact with offices, homes, cars, malls and airports to request information, benefit from the resources available, and personalize the space’s behavior. Except for confidentiality restrictions, data and tasks are always accessible and are mapped dynamically to convenient resources present in the current location. Users may extend the habitat with personal devices that seamlessly integrate with the environment. When the physical environment of a user contains hundreds of networked computer devices each of which may be used to support one or more user applications, the notion of personal computing becomes inadequate. Further, when a group of users share such a physical environment, new forms of sharing, cooperation and collaboration are possible.

Research must devise appropriate user interfaces, protocols, algorithms, data structures, services and infrastructure to migrate ubiquitous applications, make context available to those applications and secure and offer privacy to the users of ubiquitous computing applications. Since ubiquitous computing must be scalable and inexpensive, engineering ubiquitous applications and their support must become commonplace requiring standards, tools, and common components. Support for ubiquitous computing requires cyber infrastructure that both supports user ubiquitous applications requirements and safeguards the infrastructure. Major breakthroughs can be expected in creating ubiquitous applications that support significant human activities, particularly in the areas of entertainment, business, health care, and education. Creating a commercial environment in which such breakthroughs can impact all society and all nations will require considerable effort. Of particular concern is the problem of developing a trusted cyber infrastructure for ubiquitous computing. Existing computer and network architectures remain vulnerable to errors, sabotage, and theft and a more heavy reliance on ubiquitous computers will make the situation more difficult to solve. Privacy of the individual is also a major concern with the increase of information from ubiquitous computing, location awareness, and video surveillance. Another difficult problem requiring research is predicting the impact of ubiquitous computing on society. Although the understanding of user interfaces has improved, it has proved to be remarkable difficult to develop interfaces that offer accessible information processing to all members of society. Last, as in all engineering endeavors, ubiquitous computing needs a suite of evaluation methods and tools.

Joëlle Coutaz

Université Joseph Fourier
Laboratory CLIPS-IMAG
Grenoble, France
http://iihm.imag.fr/coutaz/

e-mail: Joelle.Coutaz@imag.fr
Tel: +33-4 76 51 48 54
Fax: +33-4 76 44 66 75

Short CV

I have studied computer science at University Joseph Fourier (Grenoble, France) where I obtained my doctorate in 1970 and Thèse d’Etat in 1988 in which I set the foundations of software engineering for HCI. I am the founder in 1990, and head of the HCI Group at laboratory CLIPS. I am the author of the PAC model, a conceptual software architecture model for interactive systems. I am a member of the editorial board of Interacting With Computer and formerly of the ACM TOCHI. I have been involved in the ACM CHI conference as paper and panel chair, and as member of the program committee of Mobile HCI, Ubiquitous Computing, and Ambient Intelligence. I was vice chair of the Working Group 2.7 of IFIP. I have been involved in the ESPRIT BRA/LTR project AMODEUS (1989-1995) which promoted a multidisciplinary approach to HCI. My current core research interests include context modeling as well as the concept of plasticity for distributed and migratory multimodal user interfaces. My participation in three European projects (GLOSS, FAME, CAMELEON) as well as the Dagstuhl seminar illustrates these interests.

Key words
Software aspects of HCI, software architecture modeling for interactive systems, migratory user interfaces, distributed user interfaces, plastic user interfaces.

Abstract

With the concept of ubiquitous computing, a new paradigm is emerging bringing together a wide range of disciplines. From the perspective of Human Computer Interaction, this paradigm entails a radical change in terms of design methods and development tools. In this position paper, I will stress the necessity for new tools to support the development of user interfaces (UI). I will also argue for the importance of machine perception.

User interfaces are currently designed for a known context of use based on the GUI paradigm. This paradigm supposes a fixed set of interaction resources (1 screen, a text and a pointing device). In ubiquitous computing, this stability does not hold anymore. UIs will go from stationary to migratory as well as from centralized to distributed. Distribution will happen over a dynamic set of heterogeneous interaction resources that will be borrowed and lent opportunistically. These multi-scale resources, which will range from walls to private eyes, will require that UI’s go beyond the classic zoomable model. If we want to go beyond concept demonstrations, we must dare to question the current WIMP technology and to devise new UI-centered models and infrastructures. This technology will sit at the edge of the global computing fabric to form a dynamic cohesive whole.

In addition to UI development tools, we currently need significant progress in machine perception. Too often, machine perception has been developed for its own sake, without concern for the requirements of the real world. If we want services and their UIs to dynamically accommodate the diversity of situations and contexts, we need machine perception to set the foundations for modeling context.

Beyond tools and techniques, we, as responsible researchers, must not forget Ethics. Privacy and trust are core issues. As a researcher in HCI, I am also concerned by the right balance between the anthropomorphic ‘machine’ envisioned as an equal partner, and the instrumentalist perspective where the ‘machine’ is a controllable tool.

Anind K. Dey

Senior Researcher
Intel Research Berkeley
http://www.cs.berkeley.edu/~dey

e-mail: anind@intel-research.net
Tel: +1-510-495-3012
Fax: +1-510-495-3049

Short CV
Anind Dey is a Senior Researcher at Intel Research Berkeley and an Adjunct Assistant Professor in Electrical Engineering and Computer Science at the University of California and Berkeley. He received a PhD in 2000 in Computer Science from Georgia Tech, performing his dissertation research on the topic of software architectures to support the building of context-aware computing, namely the Context Toolkit. Anind performs research at the intersection of ubiquitous computing (ubicomp) and human-computer interaction, looking at techniques for improving users’ experiences in ubiquitous computing environments and tools that make it easier for programmers to design and implement compelling ubicomp applications for users. Over the past few years, Anind has been focusing on the issues of end-user programming, privacy and ambient/peripheral displays.

Key words
Context-aware computing, human-computer interaction, end-user programming, software architectures

Abstract
One of the most important challenges in ubiquitous computing is determining how to give end users control of their smart environments. Most of the visions of ubiquitous computing include autonomous agents or programs acting autonomously on the behalf of users. It is unrealistic to expect that these agents will be able to accurately predict what users want to occur in all situations. Instead, it is imperative that end users have the ability to *control* what occurs in these environments. Specifically there are at least three important problems that need addressing: 1) how to support non-programmers/end users in building applications that support delegation of tasks to the environment (*e.g.*, context-aware computing); 2) how to protect end users’ privacy in a world of ubiquitous sensing, data synthesis and dissemination; and, 3) how to alleviate issues of information overload. End users know more about their environments than anyone else and are in a better position to specify what their applications should do than any programmer. In addition, as these environments change and evolve, end users will be the only ones available to make changes and evolve their applications. It is imperative that end users be empowered to build and evolve applications to control their ubicomp environments. On the issue of privacy, ubicomp environments are filled with sensors collecting information about users and their actions, processing this information, disseminating this information to others and taking action on it. Users must be able to take control of this information and this process of information collection and dissemination. They must be able to specify who is able to gain access to what information in what circumstances, in a tractable, non-overwhelming way. Finally, on the issue of information overload, with a greater number of sensors collecting information and a greater number of devices that can display information, there are greater opportunities for being overloaded with information. Ubicomp researchers should provide ways of presenting information that minimize information overload but maximize usefulness and timeliness of information.

Hans Gellersen

Professor for Interactive Systems
Department of Computing
Lancaster University
UK

e-mail: hwg@comp.lancs.ac.uk
Tel: +44-1524-593823
Fax: +44-1524-593608

Short CV

Hans Gellersen is Full Professor for Interactive Systems at the Department of Computing at Lancaster, U.K. His research interest is in ubiquitous computing and embedded interactive systems. This spans work on enabling technologies such as position and context sensing, on user interfaces beyond the desktop, and on embedding of interaction and intelligence in everyday artefacts. Recent work includes Smart-Its, a framework for artefact-based applications and platform for rapid prototyping of artefacts with embedded computing.
Hans initiated the HUC/Ubicomp conference series on Ubiquitous Computing and serves as editor of the Journal on Personal and Ubiquitous Computing. He is involved with major research programmes related to Ubiquitous Computing, including the Disappearing Computer initiative and the Equator project in the UK. Hans has been in his current position since 2001 and previously was affiliated with the University of Karlsruhe, Germany. He holds an MSc and a PhD in Computer Science, both from University of Karlsruhe.

Key words

Ubiquitous computing, embedded interactive systems, context-awareness

Abstract

Recent research programmes related to Ubiquitous Computing have begun to embrace embedded technologies to engage more deeply with the vision of ‘activating the world’. The Disappearing Computer projects specifically have emphasized augmentation of places and artefacts in people’s lives, to literally push computing into the background of what people care about. There has been some inspiring work on ‘smart artefacts’ as future versions of familiar things in our lives, however on a very limited scale. It is clear that interactive and intelligent behaviour can be embedded in practically everything but it is not yet understood at all how this would give rise to emergent applications, what the implications would be, and how this can be designed to be human-centred in the spirit of Weiser’s vision.
In order to work toward a better understanding, it is necessary to build experimental test-beds that push the vision, integrating not only a few artefacts in selected and relatively controlled settings, but thousands of artefacts used across largely varying settings. Among the core challenges is the development of architectures for embedded and decentralized intelligence and interaction, to allow ad hoc collections of artefacts to become more autonomous of surrounding infrastructure. This is in contrast to most current ubiquitous computing experiments which tend to be constructed around richly instrumented locations with centralized systems services – such environments can not be assumed to become ubiquitously deployed. In conjunction with a shift from environment-centric systems to decentralized systems of computational artefacts, it will also be a key challenge how to expose and explain system behaviour, and how to make artefacts and emerging applications reconfigurable/programmable by their owners/users.

Anatole Gershman

Director of Research
Accenture Technology Labs
Chicago, USA

e-mail: Anatole.v.gershman@accenture.com
Tel: +1-312 693 6613
Fax: +1-312 652 6613

Short CV

Anatole Gershman is Director of Research at Accenture Technology Labs. Under his leadership, research at the laboratories is focusing on early identification of potential business opportunities and the design of innovative applications for the home, commerce and work place of the future. The technology laboratories are conducting research in the areas of ubiquitous computing, interactive multimedia, information access and visualization, intelligent agents, and simulation and modeling. Prior to joining Accenture in 1989, Anatole spent over 15 years conducting research and building commercial systems based on Artificial Intelligence and Natural Language processing technology. He held R&D positions at Coopers & Lybrand, Cognitive Systems, Inc., Schlumberger, and Bell Laboratories. Anatole studied Mathematics and Computer Science at Moscow State Pedagogical University and received his Ph.D. in Computer Science from Yale University in 1979.

Key words

Sensors, Artificial Intelligence, Intelligent Sensor Networks, Data Mining, Visualization

Abstract

Ubiquitous computing holds enormous promise for radically transforming the way we interact with our environment. At work, in public areas and at home invisible intelligent computers will understand what we need in our specific context and bring the power of all locally available resources to satisfy those needs. They may even anticipate our needs and protect us from potential hazards. These services will help individuals as well as groups such as families and work teams. Large-scale applications of invisible ubiquitous computing will range from supply chain management and transportation to public safety and the care for the elderly. To bring these benefits to life, significant advances will have to be made in several areas of technology. First, we’ll need better, more intelligent and inexpensive sensors capable of collecting all kinds of data from the environment. These sensors will range from temperature and acceleration meters to medical monitoring devices. Of special importance are exact positioning sensors that work indoors. Sensors even at the edge of the network will have to be intelligent and provide some level of information processing in order not to flood the network with raw data. Secondly, we need intelligent sensor networks that will direct the right information to the right recipients. These networks will range from wired to mobile and from fixed to ad-hoc and self-organizing. The network intelligence will be necessary to decide where the information is going, how it should be aggregated and how it will get to its destination, which itself may be dynamic and changing. Thirdly, we need powerful and intelligent analytical tools to decide what to do when information about a person or an object reaches a decision point. Most likely, these tools will have to combine statistical observation with artificial intelligence techniques such as machine learning and case-based reasoning. Critical to the success of these tools will be their ability to handle enormous amounts of data coming from the sensor networks, much of it in real time. Finally, the people controlling such systems will need powerful visualization, knowledge discovery and collaboration tools to make invisible computing not only visible but usable and intelligible.

Achilles Kameas

Senior researcher
Research Academic Computer Technology Institute
R&D Unit 3 / DAISy group,
Patras, Greece

e-mail: Kameas@cti.gr
Tel: +30-2610-273496
Fax: +30-2610-222086

Short CV

Achilles D. Kameas (daisy.cti.gr) received his Engineering Diploma (in 1989) and his Ph.D. (in 1995, in Human-Computer Interaction), both from the Department of Computer Engineering and Informatics, Univ. of Patras, Hellas. He is an Assistant Professor with the Hellenic Open University, where he teaches software engineering. He is also a senior researcher with Research Academic Computer Technology Institute (CTI), where he is the head of Research Unit 3 (Applied Information Systems) and the founder of the Design of Ambient Intelligent Systems (DAISy) group. His research activities are currently focused in ubiquitous computing (component-based architectures, design and analysis of middleware, ontology-based service discovery and composition, end-user models and tools, application development methodologies), interfacing with biological systems (semantic characterization of plants' biological signals) and swarm intelligence applications (formal specification and analysis, synthesis and emergence of behavior, communication protocols).

Key words

ubiquitous computing, architecture, middleware, ontology, tools

Abstract

In order for ubicomp technology to become acceptable by society, we think that a breakthrough in scale will be required: apart from designing smaller, more robust, friendlier systems, its “face” and the “interfaces” it offers must become non-intrusive cognitively. This will involve the large-scale deployment of ubicomp applications, first in specialized areas (i.e. buildings, health, office environments, games) and then across all environments. To reach this point, we also need to produce results in infrastructures (so that ubicomp applications are supported) and tools (so that they are developed and used).

- Infrastructures: this translates to standardization of procedures to access and use computer-enabled services, ubiquitous interfaces, “natural” and safe interaction with ubiquitous services/applications. To achieve these we need to design appropriately generic layered architectures, design for adaptability (with emphasis in context awareness and evolution through learning), achieve real-time performance, design scalable models to manage the complexity of interactions, accommodate heterogeneity of concepts and implementations, support mobility by creating task representations, incorporate privacy and safety preserving mechanisms that are acceptable from society into systems.
- Tools: developers need processes to design, develop, deploy and evaluate ubicomp systems; these could result from combining and evolving existing ones in distributed systems, component-based systems, hardware design and complex systems. End-users need tools to help them create, adapt, use and generally manage these applications, without bothering with details about network, device compatibility, service location, etc. Moreover, they need to feel increasingly safe with this technology, so the way data and content are used must be visible and subject to user control.

We expect that major research efforts are undertook into coding, managing and representing “knowledge”, a critical element that in the above descriptions appears in many forms (descriptions, data, rules, results etc).

Morten Kyng

Department of Computer Science
University of Aarhus
Denmark

e-mail: mkyng@daimi.au.dk
Tel: +45-89 42 57 15
Fax: +45-89 42 56 24

Short CV
Morten Kyng's main research areas are participatory design, computer supported cooperative work, pervasive computing, and human-computer interaction. His main focus is currently participatory design of new paradigms for 'palpable' pervasive computing systems. That is pervasive systems that are capable of being noticed and that the users may investigate and apprehend mentally. Morten Kyng is professor of pervasive computing and coordinator for the EC project Palcom. The professorship is sponsored by Systematic Software Engineering - www.systematic.dk. Morten received his Doctor of Science from the University of Aarhus in 1996. He currently directs the Centre for Pervasive Computing - www.pervasive.dk, a national research centre with headquarters at Katrinebjerg in Aarhus. In 2001 he was, as the only European, appointed to the ACM CHI Academy for leadership in the field of computer-human interaction. From 1996 to 2002 Morten directed the Danish National Centre for IT Research.

Projects sponsored by the European Commission
Coordinator (project manager) for the project Palcom: Palpable computing – a new perspective on ambient computing. Palcom is an integrated project in the 6th Framework Programme, palcom.dk
Project manager for the project OCTOPUS (1995) on multimedia support for globally distributed cooperation.
Project manager for the ESPRIT III project EuroCODE (1993) on an open CSCW development shell.
Project manager for the University of Aarhus group in the ESPRIT II project EuroCoop (1992)

Key words
Pervasive Computing, Palpable Computing, Participatory design, Computer Support for Cooperative Work, Object-oriented analysis and design.

Abstract
Ambient or ubiquitous computing is an emerging field based on a number of insights and assumptions many of which were described by Mark Weiser in his 1991 Scientific American paper “The Computer for the 21th Century”. The promise and the ambitions are high, and several contributions illustrate the potential. This position paper explores a new perspective on ambient computing called Palpable computing. The perspective challenges some of the assumptions taken for granted in the design of ambient computing. Thus *palpable* denotes that systems are capable of being noticed and mentally apprehended. Palpable systems support people in understanding what is going on at the level they choose. Palpable systems support control and choice by people. Often the default mode for a palpable application is to suggest courses of action rather than acting automatically. Palpable computing challenges and complements ambient computing in the following ways:

ambient computing	complemented with	**palpable computing**
invisibility		visibility
construction		de-construction
scalability		understandability
heterogeneity		coherence
change		stability
sense-making and negotiation		user control and deference

Thus palpable computing complements the unobtrusive effectiveness of ambient computing with a focus on making the means of empowering people intelligible. Palpable computing supports users in coping with situations where technology is not doing the (right) job and thus enable us to create technology for a dynamic society where we cannot assume that (all of) our technology has become so natural that we use it without even thinking about it.

Spyros Lalis

Assistant Professor
Computer and Communications Department
University of Thessaly
Greece

e-mail: lalis@inf.uth.gr
Tel: +30 - 2421074978
Fax: +30 - 2421074997

Short CV

Spyros Lalis received a Diploma in Computer Engineering and a doctorate in Technical Sciences from the Swiss Federal Institute of Technology Zurich (ETHZ). Since 2002 he is Assistant Professor at the Computer and Communications Engineering Department of the University of Thessaly. Since 1997 he is Research Associate at the Institute for Computer Science of the Foundation for Research and Technology Hellas (ICS-FORTH), and since 2003 he is Research Associate at the Informatics and Telematics Institute of the Center for Research and Technology Hellas (ITI_CERTH). His interests include Programming Languages and Systems, Software Engineering, Operating Systems, Distributed Systems, Global and Ubiquitous Computing. He has participated in several international research projects. He was coordinator of 2WEAR (http://2wear.ics.forth.gr), a project funded under the FET Disappearing Computer initiative (http://www.disappearing-computer.net).

Key words

distributed systems, global computing, wearable and ubiquitous computing.

Abstract

The new era of computing is characterized by (a) the heterogeneity of computer elements in terms of processing, storage, sensing, mobility, communication and interaction capability, (b) the increased embedding of such elements into everyday objects or environments, (c) the wide range of possible element combinations that become possible to support applications, and (d) the huge span of applications in terms of lifetime, operational environment, and physical distribution/distance of their elements.

One of the main challenges is to support the flexible combination of these elements, and to perform, maintain and adjust such combinations, at runtime. This must be done in a way that relieves the application programmer from having to implement this functionality (every time from scratch) while providing enough flexibility so that it is possible to specify and control the system’s behavior in a simple way.

Context-awareness is important in order to deal with the various operational settings of applications in a flexible and proactive way and with minimal explicit input from the user. However, “low-level” context information should be combined with the user’s intention (high-level context). In turn, user intention must be captured as a combination of explicit input (commands), known plans (agendas) and sensing subsystems (monitoring -> inference). Both contextual aspects must be woven into the application and the supporting system infrastructure in an appropriate way.

Last but not least, it is perhaps interesting to challenge the traditional notion of application (a “dump” executable that is started by the user, does something and then terminates), and try to think of different metaphors, e.g. applications are composed of persistent agents that continuously evolve, and which can be suspended when showing no signs of activity and resumed whenever something “interesting” happens.

James A. Landay

Director of Intel Research Seattle
and Associate Professor at the
Dept. of Computer Science & Engineering
University of Washington
Seattle, USA

e-mail: james.a.landay@intel.com
Tel: +1 - 206 - 545-2511
Fax: +1 - 206 - 633-6504

Short CV

James Landay is a Professor of Computer Science at the University of Washington and the Director of Intel Research Seattle. He is also the chief scientist and co-founder of NetRaker Corp. He received his B.S. in electrical engineering and computer science from UC Berkeley in 1990 and his M.S. and Ph.D. from Carnegie Mellon University in 1993 and 1996, respectively. His Ph.D. dissertation was the first to demonstrate the use of sketching in user interface design tools. He has published extensively in the area of human-computer interaction, including articles on user interface design and evaluation tools, ubiquitous computing, pen-based user interfaces, mobile computing, and visual languages.

Title

Emerging Design Patterns for Ubiquitous Computing

Abstract

Design patterns are a format for capturing and sharing design knowledge. We have recently looked at a new domain for design patterns, namely ubiquitous computing. The overall goal of this work is to aid practice by speeding up the diffusion of new interaction techniques and evaluation results form researchers, presenting the information in a form more palatable and usable to practicing designers. Towards this end, we have developed an initial and emerging pattern language for ubiquitous computing, consisting of 45 pre-patterns describing application genres, physical-virtual spaces, interaction and systems techniques for managing privacy, and techniques for fluid interactions. We evaluated the effectiveness of our pre-patterns with 9 pairs of designers in helping them evaluate and design location-enhanced applications, currently the most common form of ubiquitous computing. We observed that our pre-patterns helped new and experience designers unfamiliar with ubiquitous computing, in generating and communicating ideas, and in avoiding design problems early in the design process. We are currently focusing on developing design patterns in the digital home of the future and exploring whether the emerging pattern language can help designers, as well as become the basis for end-user configuration of the digital environment.

Allan MacLean

Director
Image Semantics Ltd
Cambridge, UK

e-mail: allan.maclean@imagesemantics.com
Tel: +44 7734276000
Fax: +44 1223 422325

Short CV
I am a founder and director of Image Semantics which was set up in 2002 to develop innovative applications and services to take commercial advantage of the mass-market opportunities that are now emerging around latest generation mobile phones. Prior to this, I was with Xerox Research Centre Europe's Cambridge laboratory from its inception as Rank Xerox EuroPARC in 1987. Over the last twenty years I have worked on a wide variety of issues and problems in the broad area of interactive technologies. A common thread has been a strong grounding in use and the user, while also pushing technological and conceptual boundaries. My main research interests have focussed around moving away from the desktop PC since the early 90’s, for example, through work on media spaces and mobile computing. I also have a long standing interest in design and the design process as a way of dealing with the increasingly interdisciplinary demands that must be coordinated for the successful development of modern technologies. I worked closely with the ACM (Association for Computing Machinery) to develop relations between the former USSR and the West in the early 90’s via the East-West HCI conference series, and in the mid-90’s as a founder of the DIS (Designing Interactive Systems) conference series. I have regularly advised on funding programmes for the UK Research Councils and the European Union and am a member of the Steering Group for the EU ‘Disappearing Computer’ Programme.

Key words
Mobile applications; Interactive technologies; User perspectives; Consumer market; Design process

Abstract
I would like to explore four directions that I believe will help us work out where we need to focus research effort beyond what we are currently doing. The first two are conceptual – how we think about the core problem we are addressing. The second pair focus on how we carry out research in this area and what disciplines are involved.

Getting to the essence and fighting complexity

From a user perspective, what are the core enabling capabilities that emerge from the wide range of ubicomp applications and services we are currently pursuing? We have a tendency in research to make things too complicated to get a clear message across outside the research community. We need more reflection on work done to date to make sure we understand what is important , can communicate it clearly and have a stronger foundation for future research

Getting to grips with context

We have used the word “context” in far too generic a way over the last 15 years. Devices being aware of what is going on around them will probably be the basis of the next big leap forward in the second decade of the 21st century, but we still haven’t reached consensus on what is important here. The initial solution might be as simple as working out how to use location information effectively and in a general and useful way.

Taking the hardware seriously

Too much research is still based on developing software for off-the-shelf devices. We need more emphasis on designing the hardware as an integral part of ubicomp research, incorporating skills ranging from expertise in developing low level circuits to the external form of devices.

Taking the market seriously

We have made good progress in taking people and their needs seriously as part of our research programmes. But we still assume that because we can demonstrate that people SHOULD want the products of our research that they WILL want them. The gap is much wider than we generally appreciate. It is not enough just to involve token companies in research projects and tack on an exploitation plan as part of the proposal. One solution might be to involve people with expertise in the exploitation of technology as part of the research programmes – possibly skills such as business strategy, marketing, channel development, even venture funding.

Friedemann Mattern

Institute for Pervasive Computing
ETH Zürich
Switzerland
http://www.inf.ethz.ch/~mattern/

e-mail: mattern@inf.ethz.ch
Tel: +41 1 632 05 36
Fax: +41 1 632 16 59

Short CV
Friedemann Mattern has been a professor of computer science at ETH Zurich since 1999. He studied computer science and communications at the University of Bonn and received his PhD from the University of Kaiserslautern in 1989. He served as professor of computer science at the University of Saarbrücken from 1991-1994, and at Darmstadt University from 1994-1999. At ETH Zurich, Mattern founded the Institute for Pervasive Computing and heads the computer science department's Distributed Systems Group. His research interests include concepts of distributed computing, ubiquitous computing, and infrastructure mechanisms for dynamic networking of small and mobile devices. Mattern is the co-editor of several scientific journals, and is involved in various research projects (such as M-Lab, NCCR-MICS, Smart-Its), often in cooperation with industrial partners.

Key words
infrastructures for ubiquitous computing, applications for ubiquitous computing, implications of ubiquitous computing, sensor networks

Title
Social, Economic, and Ethical Implications of the Disappearing Computer

Abstract
The Disappearing Computer is a radical concept: With its orientation towards the public as well as the private, the personal as well as the commercial, it aspires to create technology that will accompany us throughout our entire lives. While developments in information technology never had the explicit goal of changing society, but rather did so as a side effect, the visions associated with the Disappearing Computer expressly propose to transform society by fully computerizing it. It is therefore likely that this development will have long-term consequences for our everyday lives and ethical values that are much more far-reaching than the Internet as we know it today.

However, the repercussions of such extensive integration of computer technology into our everyday lives as propagated by the Ubiquitous Computing paradigm are difficult to predict and one can only speculate. It is certainly not the washing machine querying our dirty clothes for washing instructions that will change the world. But what if parents will never lose track of their children because location sensors and communications modules are sewn into their clothes? And will producers of "smart" goods get a permanent channel to their customers, enabling new pay-per-use business models and having control over the use of their products and services? Would people feel being surrounded by an invisible and comprehensive surveillance network with all the smart objects and wireless sensors that we envision? Also, as more and more objects and environments are being equipped with Ubiquitous Computing technology, the degree of our dependence on the correct functioning of this technology increases - can we rely on it? And if artifacts become more autonomous and humans move gradually out of the loop - who is responsible if something goes wrong?

Obviously, there are more questions than answers and only the future will tell. But, maybe, we can profit by speculating about the possible consequences of this technology and evaluating it within the framework of established concepts from fields such as sociology or economics. It may thus be possible to steer the development in a direction that has more in common with Weiser's optimistic vision of the 21st century than with the depressing scenarios of some popular but not necessarily unrealistic cyberpunk scenarios.

Other issues:
- How to make sense out of all these data provided by wireless sensors?
- How can we manage all these invisible computers?
- Can we make objects smart without making them intelligent?
- Will we ever get a common and open infrastructure to support smart objects?

Paddy Nixon

Global and Pervasive Systems Group
The University of Strathclyde
Glasgow G1 1XQ, Scotland

e-mail: paddy.nixon@cis.strath.ac.uk
Tel: +44-141-548-3588
Fax: +44-141-552-5330

Short CV
Paddy Nixon is Professor of Computer Science at Strathclyde University where he runs the Global and Pervasive Systems Group. He is also research Director of the Kelvin Institute – a company developing and commercialising research in the pervasive systems domain. He holds a B.Sc. from Liverpool University, a Ph.D. from Sheffield University, and an M.A. (in J.O) from Trinity College Dublin. He is a Chartered engineer and a member of the British Computer Society. Professor Nixon’s research is focused on the following key aspects distributed systems research: 1. Theoretical and structured approaches to distributed systems construction, 2. Dynamic adaptation and composition of distributed systems, and pervasive computing. He has been co-chair of the EU Disappearing Computer Network and is co-founder of the UK Ubiquitous Computing Network of Excellence. He has been guest editor for special issues of IEEE Internet Computing Journal, The Computer Journal, The Journal of Parallel Algorithms and Architectures, and The Software Quality Journal. He has chaired 6 conferences and 3 workshops in the areas of electronic commerce, parallel and distributed systems, and smart environments. He has published five books, with 2 books under review, and over 100 publications in the areas of pervasive computing, virtual enterprises, software engineering, parallel processing, distributed systems and object orientation.

Keywords: Middleware, Context modelling, Programming Abstractions, Trust and Privacy**.**

Title
Sentient and Global Scale Ambient Systems

Abstract
The natural progression of research to commercial realisation in Ambient Systems is taking the developments from laboratory examples to real world deployments. However, implicit in all of these deployments are the limitations of the existing research developments. They are premised on: deployments of hundreds rather than billions of sensors; on local communications at the expense of the global movement of users; on limited representations of context and knowledge; and ad-hoc abstractions and programming primitives. The commercial realisation of such systems still requires significant engineering research expertise. However, to realise truly global and sentient ambient systems requires a fundamentally new set of models and approaches. Our vision is one of the sentient ambient system – one that is both globally aware and responsive, and intimately individual. Below we outline a number of fundamental research challenges that are a consequence of the need to scale up to the levels of sensors and devices implied by the ambient systems vision, and to continue to provide intimate, human control over the information flows within the environment.

Scaling: By this we consider the deployment of smart dust sized computation and sensory elements in a given environment. The numbers of entities and complexity of communication are comparable to scale of the communications in today’s internet. In short, the current models of communication, interpretation, and adaptation are not appropriate.

Matching and Discovery: One of the key requirements to the provision of globally aware services is a matching service capable of assimilating and filtering information from various sources and determining relevant matches., we need to provide matching that is consistent within some acceptable operational envelope; an operational envelope that may be different for every user, environment, or situation.

Layering, abstraction, and programming: Ambient systems development has yet to establish what the fundamental semantics of its systems are and consequently it is still missing the fundamental primitives. The only way for future ambient systems to be economically viable to develop is for there to be coherent toolsets. The only way to develop the toolsets is to discover the fundamental primitives and understand their semantics and implementation.

The baseline challenge is - how do we develop an active infrastructure that embodies this new extended sensory system and which provides to the user, application or environment an intimate local interface to global dispersed services**.**

Joseph A. Paradiso

MIT Media Laboratory
Cambridge, USA
http://www.media.mit.edu/~joep

joep@media.mit.edu
Tel: +1-617-253-8988
Fax: +1-617-253-6285

Short CV
Joseph Paradiso’s background ranges from high-energy physics detectors and spacecraft control systems to electronic musical instruments. He now explores the development and application of new sensor architectures and extremely dense sensor/processor networks for human-computer interfaces and intelligent spaces. An expert on sensing technology, he has developed a wide variety of systems that exploit many different sensor modalities to track human activity. A summa cum laude graduate of Tufts University, Paradiso received his PhD in physics from MIT as a Compton Fellow. Before joining the Media Lab, he was at ETH in Zurich working on precision drift chambers and the Draper Laboratory in Cambridge, Massachusetts, working on underwater sonar, precision alignment systems, and aerospace vehicle control. He is an associate professor and directs the Media Lab’s Responsive Environments Group, and co-directs the Things That Think Consortium, a collaboration between Media Lab researchers and industrial partners to explore the extreme future of embedded computation.

Key words
Sensor Technology, sensor networks, electronic skins, expressive interfaces, quasi-passive wakeup

Abstract
Sensor networks will provide the means for user interfaces to break out of today’s constrained platforms and permeate the environment. This produces a major shift in how sensors are used in user interfaces. Rather than relying on only one or two kinds of sensors designed a priori to measure particular parameters, many sensors will be used that don't necessarily directly measure the quantity of interest, but allow it and several other parameters to be estimated from the wealth of raw data being produced. This is analogous to vision systems in the large amounts of potentially indirect data being produced, but here the different types of sensors produce measurements of different flavors, as they look at an environment from many different perspectives. Fusing this data into dynamic features that reflect a user’s state and can infer goals is the major challenge in ubiquitous computing, and indeed incorporates many stubborn problems that have been nagging computer science for decades. As these sensor nodes generally have limited resources (e.g., power, computation capacity, communication bandwidth), they must be optimally and dynamically balanced (i.e., what sensors to look at and which features to calculate and transmit) depending on local and global context. A key challenge in power management is to have these sensor nodes spontaneously activate upon receipt of sensor signals that are passively filtered to select appropriate stimuli (what we term “quasi-passive wakeup”) – achieving this with radio (having the sensor nodes activate upon passive reception of a coded signal) is perhaps an even greater challenge. Our ability to intimately blend diverse sensors with local, interconnected processing on nodes spaced mm apart or closer promises to usher in a new generation of intelligent materials or multimodal electronic skins, where the frontiers of electronics fabrication, sensor integration, data fusion, ad hoc networking, and emergent computation intersect to launch a new field of sensing mechanisms with nearly biological complexity. Such work holds the potential for revolutionary applications in areas such as robotics, medicine, and smart materials.

Daniel M. Russell

Senior Research Scientist
User Sciences & Experience Research Lab (USER)
IBM Almaden Research Center
San Jose, USA

daniel2@us.ibm.com
Tel: +1-408-927-1907
Fax: +1-408-927-3033

Short CV

The central organizing themes of my research career has been to (1) understand the nature of how people use large & complex collections of information, and (2) to create attractive, comprehensible, and evocative user experiences of that information.

Following this lead, I work to invent new mechanisms that let us know more, perceive more richly, and comprehend the world in new ways. This focus has lead me over the past several years to work in the areas of the design of information experience, sensemaking, intelligent agents, knowledge-based assistance, information visualizations, multimedia documents, advanced design and development environments, design rationale, planning, intelligent tutoring, hypermedia, human/computer interfaces.

Most recently I've turned my attention to how large amounts of information can be worked with in many different settings, which inevitably has led me to work in ubiquitous computing, and understanding how to make the computer disappear into the work.

I am now at IBM's research center at the southern tip of Silicon Valley, the Almaden Research Center, in San José, California, USA. I have previously worked at Xerox PARC and at Apple Computer's research lab.

Key words
large shared displays

Title

Attention Shock: Living in a world of multiple competing information streams

Abstract

How do you know what you can do in a given place? How does the world inform you of possibilities and options?

Perhaps the greatest challenge facing the disappearing computer is that of attention management, or rather, human attention conservation, as we try to live in a world that grows increasingly computational and interactive. As technology increasingly shrinks computers and embeds them into more worldly stuff, many of them will become human-attention seekers. As displays become less expensive and more ubiquitous they will appear on everything and become every surface. Where displays go, advertising will follow. Where advertising goes, human attention will be increasingly diverted, and the competition for attention, or attention conversation, begins.

As a computing culture, we will need to create / design or evolve mechanisms for informing people about what computational opportunities are available (especially in a given space), while simultaneously NOT creating a world where every clock, every wall hanging, every thermostat cries out for attention. Weiser and Brown called for a world of "calm computing." We need to take that concern seriously and understand what our attentional limits are, and how to best design entire environments that are composed of many pieces from multiple makers — yet are still comfortable, workable, serene environments for humans to inhabit.

Norbert A. Streitz

Head of Research Division
AMBIENTE – Smart Environments of the Future
Fraunhofer IPSI
Dolivostr. 15, D-64293 Darmstadt, Germany
http://www.ipsi.fhg.de/ambiente, http://www.ipsi.fhg.de/~streitz

mailto: streitz@ipsi.fraunhofer.de
Tel: +49-6151-869-919
Fax: +49-6151-869-966

Short CV
Dr. Dr. Norbert A. Streitz (Ph.D. in physics, Ph.D. in psychology) is the head of the research division "AMBIENTE – Smart Environments of the Future" at the Fraunhofer institute IPSI in Darmstadt, Germany, where he also teaches at the Department of Computer Science of the Technical University Darmstadt He studied mathematics, physics, chemistry, and psychology at the University of Kiel, Germany, and psychology, education, and philosophy of science at the Technical University (RWTH) of Aachen, Germany. He was a post-doc research fellow at the University of California, Berkeley, a visiting scholar at Xerox PARC and at the Intelligent Systems Lab of MITI, Tsukuba Science City, Japan. His research interests range from Cognitive Science, Human-Computer Interaction, over Hypertext/Hypermedia and Computer-Supported Cooperative Work to Interaction Design for Ambient/ Pervasive/ Ubiquitous Computing in the context of an integrated design of real and virtual worlds. He and his team are known, e.g., for the development of Roomware®, the integration of room elements (walls, furniture) with information technology. Since 2001, he is the Chair of the Steering Group of the EU-funded proactive initiative "The Disappearing Computer (DC)", a cluster of 17 projects, and also the coordinator of the DC-project “Ambient Agoras”. Since 2003, he is the Co-Chair of CONVIVIO, the EU-funded Network of Excellence on People-Centred Design of Interactive Systems. He has published/edited 15 books and more than 90 papers presented at the relevant international conferences or in journals in his areas of interest. He serves regularly on the programme committees of these conferences and on several editorial boards (e.g., ACM TOIS - Transactions on Information Systems, Personal and Ubiquitous Computing). He is often invited to present keynote speeches to scientific as well as commercial events in Europe, USA, South America, Asia, especially in Japan.

Keywords
Interaction design, social architectural space, ambient displays, context and awareness, privacy.

Abstract
There is no doubt that the field of ubiquitous and pervasive computing is facing major problems and challenges caused by the very nature of the field, especially if it is approached in a serious way going beyond limited lab settings. Real-life applications require a huge number of sensors (challenges for mass production, integration, operability) creating an even larger amount of sensor data that have to be communicated (challenges for sensor networks), processed (challenges for pre-/post processing, aggregation), utilized by applications (challenges for inferencing, reasoning on the basis of often incomplete data), used in causing effects in the environment (challenges for actuators) as well as facilitating the information processing and decision making of humans. These are impressive technical challenges that deserve a lot of attention and effort.
On the other hand, this technology should serve a purpose – after all. This constitutes another set of challenges. It includes identifying the why and what for, the personal, social, organisational, spatial and application context. The theme of this workshop (“The Disappearing Computer”) illustrates nicely that the computer/the technology should be in the background or as the goal of the DC initiative stated: “to explore how everyday life can be supported and enhanced through the use of collections of interacting smart artefacts. Together, these artefacts will form new people-friendly environments in which the ‘computer-as-we-know-it’ has no role”. The associated objectives include: “to ensure that people's experience of these environments is both coherent and engaging in space and time”. This is the dimension I like to address and where I still see substantial deficits in research, development and exploitation deserving corresponding attention. The DC initiative made a foray into this emerging field but we still do not know enough about, e.g., what constitutes an augmented social architectural space that provides awareness and a feeling of the place and communicates its (service) potential to people and enriches their experiences. We also need to look much more at what are the issues when going beyond one person addressing groups of people and organisations and their interaction with multiple artefacts populating local and distributed spaces. Another important area is control and privacy in sensor-enriched or should I say sensor-flooded or polluted environments. Finally, I like to predict that ubiquitous computing will become a base technology that is part of our infrastructure. It will merge with other fields and will be - as hypertext functionality is now via the web – available everywhere.

Terry Winograd

Dept. of Computer Science
Stanford University
USA

e-mail: Winograd@cs.Stanford.edu
Tel: +1 650 723 2780
Fax: +1 650 723 0033

Short CV
Terry Winograd is Professor of Computer Science at Stanford University, where he directs the Interactivity Laboratory and the teaching and research program in Human-Computer Interaction Design. He is one of the principal investigators in the Stanford Digital Libraries project, and the Interactive Workspaces Project, which does research on ubiquitous computing. He recently completed a sabbatical at Google, a search engine company founded by Stanford students from his projects. In collaboration with Armando Fox at Stanford, he has led research on the Stanford Interactive Workspace, a middleware software layer and set of interaction technologies for integrated work in multi-user multi-platform settings. A key focus is in providing users with fluent interactions that provide interactive functionality in a group setting with a minimum of distraction.
http://hci.stanford.edu/winograd

Key words
Interactive workspace, fluid interaction

Title
Relating theory and practice in ubiquitous computing

Abstract
There are many research challenges from the technical side, to provide both mobile and environment-based devices that are robust, power-efficient, cost-effective, etc. Without minimizing the importance of these, I will focus on the other side of the challenge, making the ubiquitous environment comprehensible and usable for a wide class of people. As we move away from the desktop, the people who will be the “users” (though at times implicitly) of our technologies will not have either the training, the attention, or the interest in dealing with complex interfaces. On the other hand, they will tend to be more discretionary users (as opposed to productivity applications whose use is necessary for a job), so they will not use the systems unless high expectations are met. Designing appropriate interactions for this context will require new concepts and techniques beyond those that are now standard for desktop and PDA.

Successful technologies and applications are being built in many places, based on designer intuitions, careful observation of users, and devotion to iterative improvement. These will always be required, but are not sufficient to provide for the growth of the expanding world of “invisible computers” and their settings. The challenge for research is to develop generalizations and theories at an appropriate level that can distill what has been learned from experience in a way that provides systematic conceptual support and guidance for design. These will not have the straightforward quantitative nature of current fine-grained theories of motor activity and perception that have been employed in HCI, but they do need to be more generative than the broad theoretical paradigms we borrow from philosophy and conceptual branches of psychology. So the challenge has a meta-level: not just developing specific theories, but a process by which the research community can develop practices and norms that create the context for theories in practice. In doing this, we need to stay grounded in real design settings and needs, including the emerging worlds of mobile computing, network-centric interaction, and place-focused interaction.