Report on the First Summer School on Ubiquitous and Pervasive Computing

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The 2002 Summer School on Ubiquitous and Pervasive Computing was organized and run by a team of volunteers from ETH Zurich between 7th and 14th of August. The school was situated at the beautiful Dagstuhl Castle in Germany, close to the border of Luxembourg and France, and built on the success of the Ubiquitous Computing Seminar held in the same location the previous year. The lecturers were John Barton, Nigel Davies, Anind Dey, Hans Werner Gellersen, Marc Langheinrich, Friedemann Mattern, and Thad Starner.

The goal of the summer school was to provide a basic survey of the most relevant subfields, present the perspectives and the underlying technologies, identify the pertinent issues within the field and identify important research themes. Furthermore, young researchers should have the opportunity to meet distinguished scholars and contemporaries to discuss and formulate ideas.

More than 120 summer school applications were received for the sixty available places. Participant interests spanned a vast array of disciplines, ranging from industrial design to distributed systems. The majority of the participants were PhD students from various European countries, but participants from the US, Japan, and China were also present.

Lectures and participants' contributions

The summer school was organized into eighteen ninety-minute lectures, three participant workshops and three group work sessions. There was a good diversity in lecture topics, covering hardware technology and sensor systems, middleware compo-

The Lecturers

John J. Barton

HP Labs, Palo Alto CA

Nigel Davies

Department of Computer Science, University of Arizona and Computing Department, Lancaster University

Anind Dey

University of California, Berkeley and Intel Research Lab, Berkeley

Hans-Werner Gellersen

Computing Department, Lancaster University

Marc Langheinrich

Department of Computer Science, Swiss Federal Institute of Technology, ETH Zurich

Friedemann Mattern

Department of Computer Science, Swiss Federal Institute of Technology, ETH Zurich

Thad Starner

College of Computing, Georgia Institute of Technology

nents, ubiquitous application examples and relevant theory. Most lecturers stayed for the duration of the summer school, initiating impromptu discussions on a wide variety of related topics as well as providing useful and expert advice on individuals' research dissertations.

Participants attentively listening to a lecture

On arrival participants were given a dossier containing a dozen or so papers, including articles by Vannevar Bush, J.C.R. Licklider, and Mark Weiser. Group work sessions invited participants to use this material and brainstorm in sets of approximately six people on specific ubiquitous computing research issues. Discussion themes included "Design exercise: augment artifacts of the Dagstuhl environment," "What was right or wrong with older predictions and scenarios? Why?," "How will we live in twenty years –

Discussions during the coffee break

Location Awareness

(Csaba Kiss Kalló)

Location awareness was considered by many to be a key enabling technology in context-aware computing. The Active Bat indoor location system was mentioned several times in lectures and workshop presentations. Research involving ranging estimates from radio technology (in particular IEEE 802.11b wireless LAN), appears to be important in several fields and RFID tags were also used in several projects. There were many applications which used location information, including the HP Cooltown project and in establishing multi-hop communication links in an ad-hoc network environment.

User Privacy

(Alastair Beresford)

Marc Langheinrich gave an excellent series of talks on "the case for ubicomp privacy." Marc described the historical legal basis for privacy in both the US and Europe, and promoted a moral and ethical discussion on the need for user privacy in a pervasive computing environment. Privacy enhancing technologies such as P3P were described and analyzed for their effectiveness in maintaining user privacy in a ubiquitous computing world. This lecture series provided researchers with reminder on the dangers of ignoring privacy problems when designing and building pervasive computing systems.

Sharing Advice

(Ursula Kretschmer)

The participants' workshop gave a good insight into different technologies and application areas. Similarities between projects were discussed, and attendees could exchange experiences. Many participants–even those from different backgrounds–faced similar problems, so cooperation between different disciplines is very important. Small mobile devices were used by a wide variety of researchers, including Philips Research's remote controlled environment and Software Competence Center Hagenberg temperature sensing PDA. Sharing mobile device experiences and design decisions in this way will help others avoid the common pitfalls.

Research Challenges

(Martin Muehlenbrock)

The summer school provided an interesting overview of the history as well as state of the art in the field of ubiquitous computing. The presenters took the opportunity not only to describe their own work, but they set it in a broader perspective. Currently many approaches focus on simple applications and the construction of the necessary hardware. Truly complex problems have not yet been tackled, and there is a great need for the development of theoretical models and the creation of simulation and evaluation tools and methodologies. Overall, the summer school was a great opportunity to meet scholars and enthusiastic young researchers.

what can, will and should happen?" Results were then presented and discussed with the other groups at the end of the session. Group work was productive not just in the creation of novel ideas, but also gave participants a view of how those with different technical backgrounds approached a problem.

One of the unexpected highlights of the school was the excellent quality of presentation in the participants' workshops. The majority of participants gave a ten-minute talk about their particular area of research. As might be expected from the wide diversity in the participants' backgrounds, the short presentations varied in both research theme and style and served to introduce attendees' areas of research to one another.

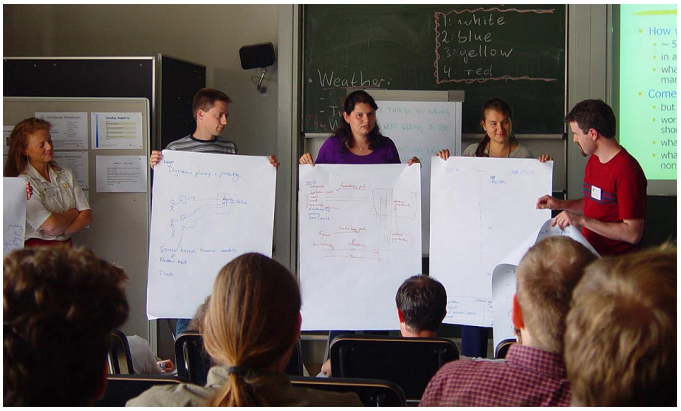
The atmosphere

Summer school participation did not consist of solely intellectual discussions: lectures and attendees alike played music and took part in team games of volleyball, table tennis and pool. Some cycled in and around the immediate countryside on Dagstuhl's bikes and made use of the extensive on-site computer science library, which thoughtfully provided a prominent display of relevant texts.

While the rest of the week contained organized lectures and group sessions, Sunday provided breathing space from the formal seminars with a trip to Château de Malbrouck in France, a cruise on the river Saar and wine tasting in Riol at the Mosel river. Other social activities included a visit to the Völklingen Ironworks on Friday evening, a barbecue and a movie session on Saturday, with short videos showing various ubiquitous computing scenarios and applications.

The accommodation, facilities and food of Dagstuhl Castle – not to forget its well-known wine cellar – were all excellent and provided an ideal setting for the summer school. The intellectual

Participants discussing the future of ubiquitous computing



Presentation of group work

Summer School Impressions

(Csaba Kiss Kalló)

One of the reasons why I participated in this summer school was to meet other PhD students and researchers in the field of pervasive computing. The organizers did their best to help participants get know each other better – and they succeeded! The local sightseeing tours were wonderful, and the evenings in the beautiful rooms of Schloss Dagstuhl relaxing. Playing one of the many available games while chatting with colleagues and the ever-changing seating plans at dinner had their effect: I think many friendships were born during our eight-day stay.

Dagstuhl Castle

atmosphere of the school was one of excitement with a liberal mix of trepidation. Many participants left with a desire to tackle and conquer this promising new field of research. In a brief survey, participants felt the summer school provided high-quality lectures coupled with plenty of opportunity to meet, discuss, and discover other researchers in similar fields. Typical statements were "Schloss Dagstuhl was very relaxing and inspiring" or "Great mix of lectures, discussions and social activities!" Overall, active involvement through group sessions and the participants' workshop were felt to be particularly useful.

The future

The biggest win from the summer school is probably yet to come: the summer school has provided a mechanism for meeting other, budding new researchers starting in the field of ubiquitous and pervasive computing. This will undoubtedly provide greater awareness of work at other universities, and a wealth of contacts attendees can draw on in future years to further their own research.

Will there be a similar summer school in the future? From the success of this year's school we would certainly expect it. While it is not yet clear where such a school could take place in 2003, it might return to Dagstuhl Castle in 2004 or 2005. More information on the 2002 summer school, including the detailed schedule and most presentations, are available at

www.inf.ethz.ch/vs/events/dag2002/

About the authors

Alastair Beresford (University of Cambridge, UK), **Csaba Kiss Kalló** (University of Trento, Italy), **Ursula Kretschmer** (Fraunhofer IGD, Germany), and **Martin Muehlenbrock** (Xerox Research Centre Europe, France) were participants of the summer school. **Friedemann Mattern** (ETH Zurich, Switzerland) was the director of the school.

The Lectures

Ubiquitous Computing Technologies (Friedemann Mattern)

The lecture gives an overview on pertinent technology trends and assesses the long-term trends and future development of relevant ubiquitous computing technologies.

Sensing in Ubiquitous Computing (Hans Gellersen)

Ubiquitous computing is closely associated with visions of smarter devices and environments capable of proactive services to their users. Obviously, sensing is a key enabling technology to make this possible. This lecture investigates what sensing is used for in ubiquitous computing, and the way this differs from more traditional sensing applications.

Context-Aware Computing (Anind Dey)

The lecture gives a historical perspective on context-aware computing: what it is and why it is important to ubiquitous computing. The talk discusses novel applications that have been built, programming support for context-aware applications and where the interesting research issues are.

Wearable Computers as Intelligent Agents (Thad Starner)

Creating intelligent agents to assist the user on a second-by-second basis during their everyday life is a unique challenge that has few parallels with the past. Research into perception, user modeling, and interface design will be necessary to create compelling assistants that do not interfere with the user's normal work and lifestyle. This lecture concentrates on development platforms, perception techniques, intelligent agents, and evaluation methods.

Smart Identification (Friedemann Mattern)

The lecture explains how RFIDs (i.e. "radio tags" or "smart labels") work and gives a short overview on smart card technologies. Current and future applications of smart labels are discussed with reference to their suitability, cost and performance.

Distributed Systems Support for Mobile and Pervasive Computing (Nigel Davies)

The lecture takes a broad look at different platforms and paradigms for mobile and pervasive computing. It mentions historical systems such as Rover and MOST and more recent efforts such as tuple-space based platforms. This lecture concludes with a look at systems such as UPnP and Jini.

A Brief Survey of US Ubicomp Projects (John Barton)

As a new field, Ubiquitous Computing is still being defined. In part ubicomp is defined by the projects that choose to be called ubicomp. The lecture gives some examples from groups in the US, using a "systems" view point to relate these projects. In addition these projects are used as examples to discuss ubiquitous computing research techniques.

A Web-Based Nomadic Computing System (John Barton)

The lecture describes a project at HP Labs to develop a Web-Based Nomadic Computing System. Physical hyperlinks connect physical entities - people, places, or things - to virtual resources on the Web. Nomadic users of handheld Web browsers can traverse links they encounter, giving them simple context-dependent views of resources around them without tracking the users. Printers, projectors, and picture frames that accept hyperlinks allow these users to bring bits of the virtual world into their physical environment.

Experiences in Developing and Deploying the Archetypal Context-Aware Computing Application (Nigel Davies)

The lecture looks at research work in the field of context-aware tour guides. It mentions past, present and future research and focuses on GUIDE as a case study of the practical issues in deploying ubicomp systems.

Augmentation of Environments (Anind Dey)

To aid intuitive interaction with a pervasive computing platform we often augment people and objects or the environment itself. This lecture discusses when the two augmentation methods are best used alone or combined for supporting novel interaction. Examples are discussed to show when it is appropriate to use a hybrid solution or one technique alone.

Computer-Augmented Environments: Back to the Real World (Hans Gellersen)

The aim of this talk is to convey a design-driven perspective of ubiquitous computing which is based on

the primacy of the physical world and the ideal of introducing computing technology unobtrusively. It discusses design affordances of physical artefacts and structures, and reviews research work on augmentation of artefacts for digital interaction (e.g. tangible user interfaces, and ambient displays).

Design Exercise on Computer-Augmented Environments (Hans Gellersen)

Participants break up into small groups, and each group gets an assignment for augmentation of a set of artefacts or a place at Dagstuhl.

Ubiquitous Exercise (John Barton)

This exercise tries to imagine some of the potential in pervasive computing and experience some of the challenges. Participants break up into teams; each team is assigned two fantasy venues, for example a school, a home, an office, a train, a museum, and a shopping area. The goal for the exercise is to imagine a useful and/or pleasant experience using any of this future technology.

Simulation as a Tool for Research in Ubiquitous Computing (John Barton)

Ubiwise is an open-source simulator for ubiquitous computing. The simulator concentrates on computation and communications devices, either integrated with physical environments or carried by people. It maintains a three-dimensional model of a physical environment viewed by users on a desktop computer through two windows.

Physical-Virtual Integration, Ubicomp Applications, Ubicomp Implications (Friedemann Mattern)

The lecture describes how smart labels, wireless sensors, embedded processors, together with the Internet backend infrastructure contribute to the integration of the physical world and the virtual world. Smart, everyday objects enable many new applications and business ideas, and create unique opportunities and challenges. Living in a smart environment has interesting consequences however.

Power and Heat in Ubiquitous Computing (Thad Starner)

RAM size, CPU speed, and hard disk storage size have increased exponentially over the past 10 years; mobile device battery energy density has increased by less than a factor of 3. Thus, energy must be a "first-class" design issue whenever discussing devices for mobility or for distribution into an unpowered environment. In addition, the heat generated from using this energy can prove to be a limiting factor in speed of computation. The lecture explores alternative ways of powering and cooling ubiquitous computing devices, discusses a basic overview of the physics involved, and provides the basic mathematical tools needed to analyze a system. Emphasis is on wearable systems and designing computing infrastructure for developing nations.

Evaluation of Ubicomp Applications and Systems (Anind Dey)

This lecture discusses the traditional systems and HCI-based methods for evaluating desktop applications and discusses which of these approaches are or are not appropriate for ubiquitous computing and why.

The Case for Ubicomp Privacy (Marc Langheinrich)

The lecture explores the nature of privacy, its history and driving factors, and how these will influence the way we perceive and value our privacy in a world full of smart, communicating objects that monitor our every move.

Tools for Ubicomp Privacy (Marc Langheinrich)

This lecture looks at some privacy-enhancing technologies and examines if and how these present a viable option for keeping our privacy in a future full of ubiquitous computing. Many experts agree that technology alone is not sufficient, but that legal means must complement any technical solution. The lecture gives a brief overview on what kinds of laws exist worldwide and what use they can be in the future.

Collaborative Augmented Reality (Mark Billinghurst)

Augmented Reality (AR) interfaces typically involve the overlay of virtual imagery over the real world. This presentation describes how AR techniques can be used to enhance face-to-face and remote collaboration. Augmented reality can be used to restore spatial cues normally missing in remote collaboration and provide an intuitive way of interacting with virtual models in a face-to-face setting.