

# Preface

Welcome to the proceedings of PERVASIVE 2004, the 2<sup>nd</sup> International Conference on Pervasive Computing and the premier forum for the presentation and appraisal of the most recent and most advanced research results in all foundational and applied areas of pervasive and ubiquitous computing. Considering the half-life period of technologies and knowledge this community is facing, PERVASIVE is one of the most vibrant, dynamic, and evolutionary among the computer-science-related symposia and conferences.

The research challenges, efforts, and contributions in pervasive computing have experienced a breathtaking acceleration over the past couple of years, mostly due to technological progress, growth, and a shift of paradigms in computer science in general. As for technological advances, a vast manifold of tiny, embedded, and autonomous computing and communication systems have started to create and populate a pervasive and ubiquitous computing landscape, characterized by paradigms like autonomy, context-awareness, spontaneous interaction, seamless integration, self-organization, ad hoc networking, invisible services, smart artifacts, and everywhere interfaces. The maturing of wireless networking, miniaturized information-processing possibilities induced by novel microprocessor technologies, low-power storage systems, smart materials, and technologies for motors, controllers, sensors, and actuators envision a future computing scenario in which almost every object in our everyday environment will be equipped with embedded processors, wireless communication facilities, and embedded software to perceive, perform, and control a multitude of tasks and functions. Since many of these objects are already able to communicate and interact with global networks and with each other, the vision of context-aware “smart appliances” and “smart spaces” has already become a reality. Service provision is based on the ability of being aware of the presence of other objects or users, and systems can be designed in order to be sensitive, adaptive, and responsive to their needs, habits, and even emotions. With pervasive computing technology embodied into real-world objects like furniture, clothing, crafts, rooms, etc., those artifacts also become the interface to “invisible” services and allow them to mediate between the physical and digital (or virtual) world via natural interaction – away from desktop displays and keyboards. All these observations pose serious challenges to the conceptual architectures of computing, and the related engineering disciplines in computer science. PERVASIVE rises to those challenges.

A program committee of 30 leading scientists, together with the help of external expert reviewers, shaped the PERVASIVE 2004 scientific program, the incarnation of which you now hold in your hands. Upon the call for papers, 278 submissions were received for consideration in the conference program – 212 for the *paper* track (including 8 tech-notes), 49 for the *hot spot paper* track, and 17 for the *video paper* track. In the *paper* track, each submission was assigned for

review to at least three program committee members, who in turn often involved further experts in the review process, so that each paper received at least three (on average 3.27, at most 8) independent reviews. After a lively discussion in the program committee meeting on December 13, 2003, assessing the scientific quality and merits of each individual submission on top of the scoring it received from reviewers, 27 papers were accepted for presentation at PERVASIVE 2004 (12.7% acceptance). One accepted paper had to be withdrawn by the authors for restricted corporate reasons. Out of the 27 papers 19 were accepted in the category *regular papers* and 8 in the category *tech-notes*. Tech-notes are not to be understood as short papers condensed into fewer pages, but are intended to present pointed results at a high level of technicality in a very focused and compact format.

The PERVASIVE 2004 venue and presentation schedule was to some extent experimental, but appealing and promising. While an international doctoral colloquium preceded the main conference on April 18–19 at the University of Linz, tutorials and workshops opened the PERVASIVE 2004 activities in Vienna on April 20. The workshop topics expressed a good blend of topical research issues emerging under the pervasive computing umbrella: Gaming Applications in Pervasive Computing Environments (W1), Toolkit Support for Interaction in the Physical World (W2), Memory and Sharing of Experiences (W3), Computer Support for Human Tasks and Activities (W4), Benchmarks and a Database for Context Recognition (W5), SPPC: Security and Privacy in Pervasive Computing (W6), and Sustainable Pervasive Computing (W7). Technical paper sessions were scheduled from April 21 through April 23, highlighted by two very distinguished keynote speeches, and an inspiring banquet speech. A special PERVASIVE 2004 Video Night event presented video contributions in a lively format in a marvelous, historic place: the festival hall of the University of Vienna. All video clips are included in the PERVASIVE 2004 Video DVD. All doctoral colloquium papers, hot spot papers, and video papers are published in the “Advances in Pervasive Computing” book of the OCG (Vol. 176, ISBN 3-85403-176-9).

We want to thank all the people on the program committee and the volunteer reviewers (listed on the following pages) with sincere gratitude for their valuable assistance in this very difficult task of reviewing, judging, and scoring the technical paper submissions, as well as for their upright and factual contributions to the final decision process. We particularly wish to thank Albrecht Schmidt (Ludwig-Maximilians-Universität München) for being a very pragmatic workshop chair; Gabriele Kotsis (Johannes Kepler University Linz) for chairing the doctoral colloquium and for her pioneering work in making the colloquium ECTS credible; Horst Hörtner from the AEC (Ars Electronica Center) Future Lab for chairing the video track, as well as his team for the support in getting the PERVASIVE 2004 Video DVD produced; Rene Mayrhofer and Simon Vogl (both Johannes Kepler University Linz) for chairing the tutorials track; and Karin Anna Hummel (University of Vienna) and Rene Mayrhofer for their excellent work as publicity co-chairs.

From the many people who contributed to make PERVASIVE 2004 happen, our special thanks go to Gabriele Kotsis, president of the OCG (Oesterreichische Computergesellschaft), and her team headed by Eugen Mühlvenzl for co-organizing this event. As in many previous events of this nature, she was the real “organizational memory” behind everything – PERVASIVE 2004 would not have come to happen without her help. Warmest thanks go to both the Rektor of the University of Linz, Rudolf Ardel, and the Rektor of the University of Vienna, Georg Winckler, for hosting PERVASIVE 2004. For their invaluable support making PERVASIVE 2004 a first-rank international event we thank Reinhard Göbl (Austrian Ministry of Transport, Innovation and Technology), Erich Prem (Austria’s FIT-IT Embedded Systems Program), and Günter Haring (University of Vienna). Jörgen Bang Jensen, CEO of Austria’s mobile communications provider ONE, Florian Pollack (head of ONE Mobile Living), and Florian Stieger (head of ONE Smart Space) generously helped in facilitating PERVASIVE 2004 and hosted the program committee meeting in ONE’s smart space. Finally, we are grateful for the cooperative interaction with the organizers of the UbiComp conference series and their helpful support in finding the right time slot for this and future PERVASIVE conferences – PERVASIVE is planned to happen annually in spring, UbiComp in fall. Particular thanks go to Gregory Abowd (Georgia Institute of Technology), Hans-Werner Gellersen (Lancaster University), Albrecht Schmidt (Ludwig-Maximilians-Universität München), Lars Erik Holmquist (Viktoria Institute), Tom Rodden (Nottingham University), Anind Dey (Intel Research Berkeley), and Joe McCarthy (Intel Research Seattle) for their mentoring efforts – we look forward to a lively and sisterly interaction with UbiComp.

Finally, this booklet would not be in your hands without the hard work and selfless contributions of Rene Mayrhofer, our technical editor, and the patience and professional support of Alfred Hofmann and his team at Springer-Verlag. Last but not least we would like to express our sincere appreciation to the organizing committee at the Institute for Pervasive Computing at the University of Linz, in particular Monika Scholl, Sandra Derntl, and Karin Haudum, as well as Rene Mayrhofer, Simon Vogl, Dominik Hochreiter, Volker Christian, Wolfgang Narzt, Hans-Peter Baumgartner, Clemens Holzmann, Stefan Oppl, Manfred Hechinger, Günter Blaschek, and Thomas Scheidl.

The numerous authors who submitted papers, expressing their interest in PERVASIVE as the outlet for their research work, deserve our deepest thanks. It is their work – very often conducted in selfless and expendable efforts – that gives PERVASIVE its special vitality. We wish to strongly encourage the authors not presenting this year to continue their endeavors, and the participants new to PERVASIVE to remain part of it by submitting next year. We all hope that this year’s program met with your approval, and we encourage you to actively contribute to (and thus steer) future PERVASIVE events.

# Organization

PERVASIVE 2004, the second in a series of international conferences on Pervasive Computing, took place in Linz and Vienna, Austria from April 18 to 23, 2004. It was organized by the Department of Pervasive Computing, Johannes Kepler University of Linz, in cooperation with the Oesterreichische Computergesellschaft.

## Executive Committee

General Chair	Friedemann Mattern (ETH Zurich, Switzerland)
Program Chair	Alois Ferscha (Johannes Kepler University Linz, Austria)
Doctoral Colloquium Chair	Gabriele Kotsis (Johannes Kepler University Linz, Austria)
Workshops Chair	Albrecht Schmidt (Ludwig-Maximilians-Universität, Germany)
Video Chair	Horst Hörtnner (Ars Electronica Center, Austria)
Tutorial Co-chairs	Rene Mayrhofer (Johannes Kepler University Linz, Austria) and Simon Vogl (Johannes Kepler University Linz, Austria)
Organization Chair	Eugen Mühlvenzl (Oesterreichische Computergesellschaft, Austria)
Finance Co-chairs	Alois Ferscha (Johannes Kepler University Linz, Austria) and Gabriele Kotsis (Oesterreichische Computergesellschaft, Austria)
Technical Editor	Rene Mayrhofer (Johannes Kepler University Linz, Austria)
Publicity Co-chairs	Karin Anna Hummel (University of Vienna, Austria) and Rene Mayrhofer (Johannes Kepler University Linz, Austria)

## Program Committee

Gregory Abowd, Georgia Institute of Technology, USA  
Michael Beigl, TecO, University of Karlsruhe, Germany  
Mark Billinghurst, University of Washington, USA  
David De Roure, University of Southampton, UK

Anind Dey, Intel Research, USA  
Elgar Fleisch, Universität St. Gallen, Switzerland  
Hans Werner Gellersen, Lancaster University, UK  
Lars Erik Holmquist, Viktoria Institute of Technology, Sweden  
Horst Hörtner, Ars Electronica Center, Austria  
Tim Kindberg, Hewlett-Packard Laboratories Bristol, UK  
Gerd Kortuem, University of Lancaster, UK  
Gabriele Kotsis, Johannes Kepler University Linz, Austria  
Antonio Krüger, Saarland University, Germany  
Marc Langheinrich, ETH Zurich, Switzerland  
Max Mühlhäuser, Technische Universität Darmstadt, Germany  
Joe Paradiso, MIT Media Laboratory, USA  
Tom Pfeifer, TSSG, Waterford Institute of Technology, Ireland  
Jun Rekimoto, Sony Computer Science Laboratories, Japan  
Thomas Rist, DFKI Standort Saarbrücken, Germany  
Tom Rodden, Nottingham University, UK  
Anthony Savidis, ICS Forth, Greece  
Bernt Schiele, ETH Zurich, Switzerland  
Dieter Schmalstieg, TU Vienna, Austria  
Albrecht Schmidt, Ludwig-Maximilians-Universität Munich, Germany  
Vincent Stanford, NIST, USA  
Thad Starner, Georgia Institute of Technology, USA  
Franco Zambonelli, University of Modena and Reggio Emilia, Italy  
Albert Zomaya, University of Sydney, Australia

## Reviewers

Erwin Aitenbichler, TU Darmstadt, Germany  
Stavros Antifakos, ETH Zurich, Switzerland  
Gerhard Austaller, TU Darmstadt, Germany  
Yuji Ayatsuka, Sony Computer Science Laboratories, Japan  
Jonathan Bachrach, MIT Computer Science & Artificial Intelligence Lab, USA  
Stephan Baldes, DFKI Saarbrücken, Germany  
Istvan Barakonyi, TU Vienna, Austria  
Steven Bathiche, Microsoft, USA  
Martin Bauer, University of Stuttgart, Germany  
Hans-Peter Baumgartner, Johannes Kepler University Linz, Austria  
Jörg Baus, Saarland University, Germany  
Ari Benbasat, MIT Media Laboratory, USA  
Alastair Beresford, University of Cambridge, UK  
Ansgar Bernardi, DFKI Kaiserslautern, Germany  
Aggelos Bletsas, MIT Media Laboratory, USA  
Juergen Bohn, ETH Zurich, Switzerland  
Gaetano Borriello, University of Washington, USA

Boris Brandherm, Saarland University, Germany  
Elmar Braun, TU Darmstadt, Germany  
Sonja Buchegger, EPFL, Switzerland  
Andreas Butz, Saarland University, Germany  
Giacomo Cabri, University of Modena and Reggio Emilia, Italy  
Eduardo Carrillo, Universidad de Valencia, Spain  
Brian Clarkson, Sony Computer Science Laboratories, Japan  
Christian Decker, TecO, University of Karlsruhe, Germany  
Klaus Dorfmueller-Ulhaas, Universität Augsburg, Germany  
Christoph Endres, Saarland University, Germany  
Mattias Esbjörnsson, Interactive Institute, Sweden  
Petra Fagerberg, Swedish Institute of Computer Science, Sweden  
Mikael Fernström, University of Limerick, Ireland  
Luca Ferrari, University of Modena and Reggio Emilia, Italy  
Alois Ferscha, Johannes Kepler University Linz, Austria  
Joe Finney, Lancaster University, UK  
Christian Floerkemeier, ETH Zurich, Switzerland  
Lalya Gaye, Viktoria Institute, Sweden  
Matthias Gerlach, Fraunhofer FOKUS Berlin, Germany  
Peter Gober, Fraunhofer FOKUS Berlin, Germany  
Jacques Govignon, Draper Laboratory, USA  
Raphael Grasset, INRIA, France  
Thomas Grill, Johannes Kepler University Linz, Austria  
Tom Gross, Bauhaus University Weimar, Germany  
Susanne Guth, Wirtschafts-Universität Vienna, Austria  
Michael Halle, Harvard Medical School, USA  
Michael Haller, Fachhochschule Hagenberg, Austria  
Andreas Hartl, TU Darmstadt, Germany  
Ralf Hauber, Johannes Kepler University Linz, Austria  
Mike Hazas, Lancaster University, UK  
Manfred Hechinger, Johannes Kepler University Linz, Austria  
Andreas Heinemann, TU Darmstadt, Germany  
Ken Hinckley, Microsoft Research, USA  
Helmut Hlavacs, University of Vienna, Austria  
Jörg Hähner, University of Stuttgart, Germany  
Maria Håkansson, Viktoria Institute, Sweden  
Tobias Höllerer, University of California, USA  
Jens Hünerberg, Fraunhofer FOKUS Berlin, Germany  
Philipp Hünerberg, Fraunhofer FOKUS Berlin, Germany  
Ismail Khalil Ibrahim, Johannes Kepler University Linz, Austria  
Sozo Inoue, Kyushu University, Japan  
Stephen Intille, MIT Department of Architecture and Planning, USA  
Robert Jacob, Tufts University, USA  
Anthony Jameson, DFKI Saarbrücken, Germany  
Jussi Kangasharju, TU Darmstadt, Germany

Guenter Karjoth, IBM Research, Switzerland  
Oliver Kasten, ETH Zurich, Switzerland  
Hannes Kaufmann, TU Vienna, Austria  
Nicky Kern, ETH Zurich, Switzerland  
Engin Kirda, Technical University of Vienna, Austria  
Georg Klein, Cambridge University, UK  
Gudrun Klinker, Technical University of Munich, Germany  
Michimune Kohno, Sony Computer Science Laboratories, Japan  
Christian Kray, Lancaster University, UK  
Michael Kreutzer, University of Freiburg, Germany  
Albert Krohn, TecO, University of Karlsruhe, Germany  
Reinhard Kronsteiner, Johannes Kepler University Linz, Austria  
John Krumm, Microsoft Research, USA  
Alexander Kröner, DFKI Saarbrücken, Germany  
Uwe Kubach, SAP AG, Germany  
James L. Crowley, INRIA, France  
Anton L. Fuhrmann, VRVis Research Center, Austria  
Mathew Laibowitz, MIT Media Laboratory, USA  
Markus Lauff, SAP AG, Germany  
Florian Ledermann, TU Vienna, Austria  
Joshua Lifton, MIT Media Laboratory, USA  
Tobias Limberger, TU Darmstadt, Germany  
Sara Ljungblad, Viktoria Institute, Sweden  
Asa MacWilliams, Technische Universität München, Germany  
Carl Magnus Olsson, Viktoria Institute, Sweden  
Rainer Malaka, European Media Lab, Germany  
Marco Mamei, University of Modena and Reggio Emilia, Italy  
Heiko Maus, DFKI Kaiserslautern, Germany  
Rene Mayrhofer, Johannes Kepler University Linz, Austria  
Joe McCarthy, Intel Research, USA  
Florian Michahelles, ETH Zurich, Switzerland  
Martin Mueller, Universität Augsburg, Germany  
Joe Newman, TU Vienna, Austria  
Daniela Nicklas, University of Stuttgart, Germany  
Ian Oakley, Media Lab Europe, Ireland  
Roy Oberhauser, Siemens AG, Germany  
Mattias Östergren, Interactive Institute, Sweden  
Stefan Oppl, Johannes Kepler University Linz, Austria  
Steven Peters, MIT Computer Science & Artificial Intelligence Lab, USA  
Mario Pichler, SCCH, Austria  
Wayne Piekarski, University of Southern Australia, Australia  
Claudio Pinhanez, IBM Research, USA  
Ivan Poupyrev, Sony Computer Science Laboratories, Japan  
Daniel Prince, Lancaster University, UK  
Thomas Psik, TU Vienna, Austria

Aaron Quigley, University of Sydney, Australia  
Ilja Radusch, Technical University of Berlin, Germany  
Jo Reid, Hewlett-Packard Laboratories Bristol, UK  
Gerhard Reitmayr, TU Vienna, Austria  
Christian Reuschling, DFKI Kaiserslautern, Germany  
Matthias Ringwald, ETH Zurich, Switzerland  
Kay Roemer, ETH Zurich, Switzerland  
Michael Rohs, ETH Zurich, Switzerland  
Thomas Roth-Berghofer, DFKI Kaiserslautern, Germany  
Guido Rößling, TU Darmstadt, Germany  
Daniel Salber, IBM T.J. Watson Research Center, USA  
Johan Sanneblad, Viktoria Institute, Sweden  
Josef Scharinger, Johannes Kepler University Linz, Austria  
Chris Schmandt, MIT Media Laboratory, USA  
Michael Schmitz, Saarland University, Germany  
Georg Schneider, Applied University of Trier, Germany  
Dirk Schnelle, TU Darmstadt, Germany  
Thomas Schoch, ETH Zurich, Switzerland  
Sven Schwarz, DFKI Kaiserslautern, Germany  
Wieland Schwinger, Johannes Kepler University Linz, Austria  
Jochen Schönfeld, Fraunhofer FOKUS Berlin, Germany  
Jennifer Sheridan, Lancaster University, UK  
Tobias Skog, Viktoria Institute, Sweden  
Christoph Stahl, Saarland University, Germany  
Christian Stary, Johannes Kepler University Linz, Austria  
Martin Strohbach, Lancaster University, UK  
Carl-Fredrik Sørensen, Norwegian University of Science and Technology, Norway  
Shigeru Tajima, Sony Computer Science Laboratories, Japan  
Peter Tandler, FHG IPSI, Germany  
Andreas Uhl, University of Salzburg, Austria  
Kristof Van Laerhoven, Lancaster University, UK  
Ludger van Elst, DFKI Kaiserslautern, Germany  
Hans van der Heijden, Vrije Universiteit Amsterdam, The Netherlands  
Simon Vogl, Johannes Kepler University Linz, Austria  
Harald Vogt, ETH Zurich, Switzerland  
Richard W. DeVaul, MIT Media Laboratory, USA  
Daniel Wagner, TU Vienna, Austria  
Rainer Wasinger, DFKI, Germany  
Daniel Weitmann, Energie AG Linz, Austria  
Frank Wittig, Saarland University, Germany  
Ylva Wridell, Viktoria Institute, Sweden  
Tobias Zimmer, TecO, University of Karlsruhe, Germany  
Alf Zugenmaier, Microsoft Research, UK



## **Sponsoring Institutions**

Austrian Ministry of Transport, Innovation and Technology

FIT-IT Embedded Systems

Forschungsförderungsfonds für die Gewerbliche Wirtschaft

Oesterreichische Computergesellschaft

Land Oberösterreich

Stadt Linz

Stadt Wien