## Lecture Notes in Computer Science

6696

Commenced Publication in 1973
Founding and Former Series Editors:
Gerhard Goos, Juris Hartmanis, and Jan van Leeuwen

#### **Editorial Board**

**David Hutchison** 

Lancaster University, UK

Takeo Kanade

Carnegie Mellon University, Pittsburgh, PA, USA

Josef Kittler

University of Surrey, Guildford, UK

Jon M. Kleinberg

Cornell University, Ithaca, NY, USA

Alfred Kobsa

University of California, Irvine, CA, USA

Friedemann Mattern

ETH Zurich. Switzerland

John C. Mitchell

Stanford University, CA, USA

Moni Naor

Weizmann Institute of Science, Rehovot, Israel

Oscar Nierstrasz

University of Bern, Switzerland

C. Pandu Rangan

Indian Institute of Technology, Madras, India

Bernhard Steffen

TU Dortmund University, Germany

Madhu Sudan

Microsoft Research, Cambridge, MA, USA

Demetri Terzopoulos

University of California, Los Angeles, CA, USA

Doug Tygar

University of California, Berkeley, CA, USA

Gerhard Weikum

Max Planck Institute for Informatics, Saarbruecken, Germany

Kent Lyons Jeffrey Hightower Elaine M. Huang (Eds.)

# Pervasive Computing

9th International Conference, Pervasive 2011 San Francisco, USA, June 12-15, 2011 Proceedings



#### Volume Editors

Kent Lyons Intel Labs, Intel Corporation 2200 Mission College Blvd. Santa Clara, CA 95052, USA, E-mail: kent.lyons@intel.com

Jeffrey Hightower Google, Seattle 651 N 34th Street Seattle, WA 98103, USA

E-mail: jeffrey.hightower@gmail.com

Elaine M. Huang University of Zurich Department of Informatics Binzmühlestrasse 14 8050 Zurich, Switzerland, E-mail: huang@ifi.uzh.ch

ISSN 0302-9743 e-ISSN 1611-3349 ISBN 978-3-642-21725-8 e-ISBN 978-3-642-21726-5 DOI 10.1007/978-3-642-21726-5 Springer Heidelberg Dordrecht London New York

Library of Congress Control Number: 2011929025

CR Subject Classification (1998): C.2, H.4, D.2, H.5, H.3

LNCS Sublibrary: SL 3 – Information Systems and Application, incl. Internet/Web and HCI

© Springer-Verlag Berlin Heidelberg 2011

This work is subject to copyright. All rights are reserved, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, re-use of illustrations, recitation, broadcasting, reproduction on microfilms or in any other way, and storage in data banks. Duplication of this publication or parts thereof is permitted only under the provisions of the German Copyright Law of September 9, 1965, in its current version, and permission for use must always be obtained from Springer. Violations are liable to prosecution under the German Copyright Law.

The use of general descriptive names, registered names, trademarks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

Typesetting: Camera-ready by author, data conversion by Scientific Publishing Services, Chennai, India

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

## Preface

On behalf the Program Co-chairs as well as the entire Organizing Committee, we welcome you to the proceedings of Pervasive 2011—the 9th International Conference on Pervasive Computing. This year's conference was held in San Francisco, California, and marked the first time that this premiere forum for research in the field of pervasive and ubiquitous computing was held in the USA.

Pervasive 2011 received a total of 93 submissions to the paper track, consisting of 70 full-length paper submissions (up to 18 pages) and 23 note-length submissions (up to 8 pages). A rigorous review process was conducted by a Program Committee of 27 recognized experts in the field of pervasive computing from 10 different countries and from both academia and industry. Every submission was evaluated in a double-blind review process by at least two Program Committee(PC) members and two external reviewers. In all, 174 external reviewers participated in the process in addition to the committee. The review phase was followed by an online discussion in which both the PC members and external reviewers took part. The final discussion and subsequent selection of technical program papers and notes happened during a two-day PC meeting in December 2010 in Seattle, Washington, hosted in part by Intel Labs Seattle through the use of their facility. Ultimately, 22 submissions were selected for inclusion in the technical program, among them 19 full papers and 3 notes, for a total acceptance rate of 23.7%. The selected papers are the work of 96 different authors from 34 international industrial and academic institutions.

As in previous years, Pervasive 2011 showcased a wide range of research activities in addition to the technical program that is presented in this volume. This year's categories of participation included a full-day of workshops prior to the technical program, as well as videos, demonstrations, and posters to accommodate the presentation and discussion of research in ways appropriate to its current state. Additionally, a Doctoral Consortium for senior PhD students occurred in conjunction with ISWC 2011, the co-located 15th International Symposium on Wearable Computers. The accepted submissions in these additional categories are not published in this volume, but can be found in the adjunct proceedings for Pervasive 2011.

Pervasive 2011 was the direct result of the dedicated effort of numerous volunteers. We want to thank the Conference Committee members for their hard work and attention to detail in making sure each aspect of the conference came together. The Program Committee and reviewers worked diligently to assemble a terrific program. We also wish to thank the staff of events for their assistance with the management of the conference and our sponsors for helping make Pervasive 2011 a success.

June 2011

Kent Lyons Jeff Hightower Elaine M. Huang

## Organization

## Conference Committee

Conference Chair Kent Lyons, Intel, USA Program Co-chairs Jeff Hightower, Google, USA

Elaine M. Huang, University of Zurich,

Switzerland

Demos Tico Ballagas, Nokia Research Center,

Palo Alto, USA

Daniela Rosner, UC Berkeley, USA

Posters Oliver Amft, TU Eindhoven, The Netherlands

Kurt Partridge, PARC, USA

Workshops Mirco Musolesi, University of St. Andrews, UK

Alexander Varshavsky, AT&T Labs, USA

Daniel Roggen, ETH Zurich, Switzerland Gerd Kortuem, Lancaster University, UK

Gerd Kortuem, Lancaster University, UK Fahim Kawsar, Bell Labs, Belgium and

Lancaster University, UK

Publicity Andreas Bulling, University of Cambridge, UK

Local Arrangements Trevor Pering, Intel, USA

Web Nirmal J. Patel, Georgia Tech, USA Sponsorship Thad Starner, Georgia Tech, USA

## Program Committee

Videos

**Publications** 

Andreas Bulling University of Cambridge, UK

Alexander Varshavsky AT&T Labs, USA

Antonio Krger DFKI and Saarland University, Germany

Bashar Nuseibeh Open University, UK

Chris Schmandt MIT, USA Daniel Avrahami Intel Labs, USA

Florian Michahelles ETH Zurich, Switzerland

Frank Bentley Motorola, USA

Hao-Hua Chu National Taiwan University, Taiwan James Scott National Taiwan University, Ta

Jens Grossklags Penn State, USA
Jin Nakazawa Keio University, Japan
John Krumm Microsoft Research, USA
Jon Froehlich University of Washington, USA
Judy Kay University of Sydney, Australia

Kay Connelly Indiana University, USA

Kurt Partridge PARC, USA

#### VIII Organization

Leila Takayama Willow Garage, USA Lena Mamykina Columbia University, USA Mike Hazas Lancaster University, UK

Minkyong Kim IBM T.J. Watson Research Center, USA

Nic Marquardt University of Calgary, Canada Patrick L. Olivier Newcastle University, UK

Rene Mayrhofer Upper Austria University of Applied Sciences,

Austria

Shin'ichi Konomi Tokyo Denki University, Japan Shwetak Patel University of Washington, USA

Tico Ballagas Nokia Research Center, Palo Alto, USA

## **Steering Committee**

A.J. Brush Microsoft Research, USA
Hans Gellersen Lancaster University, UK
Anthony LaMarca Intel Research, USA
Marc Langheinrich ETH Zurich, Switzerland
Aaron Quigley University of St. Andrews, UK

Hide Tokuda Keio University, Japan

Khai Truong University of Toronto, Canada

## Reviewers

Stephen Brewster Sunny Consolvo Wael Abd-Almageed Sharad Agarwal Gregor Broll David Cooper Manfred Aigner Leah Buechley Scott Counts Fahd Albinali Andreas Bulling Landon Cox Swamy Ananthanarayan Tiago Camacho Florian Daiber Lisa Anthony Andrew Campbell David Evans Lora Appel Ricardo Chavarriaga Eval de Lara Ismail Arai Ling-jyh Chen Dave Dearman Daniel Avrahami Guanling Chen Anind Dev Tico Ballagas Yu-Chung Cheng Travis Devle Luciano Baresi Kunigunde Cherenack Tawanna Dillahunt Aaron Beach Mauro Cherubini Sandra Dominikus Marek Bell Marshini Chetty Steven Dow Hrvoje Benko Keith Cheverst Frank Bentley

Naranker Dulay Schahram Dustdar Tanzeem Choudhury Alastair Beresford Marc Christie Nathan Eagle Claudio Bettini Hao-Hua Chu David Evans Jon Bird Jaewoo Chung Benjamin Fabian Jan Borchers Elizabeth Churchill Benedict Fehringer Gaetano Borriello Anthony Collins Steven Feiner Nick Brachet Kay Connelly Mirko Fetter

Laura Forlano Jodi Forlizzi Adrian Friday Jon Froehlich Raghu Ganti Lalya Gaye Sven Gehring Hans Gellersen Joy Ghosh

Daniel Greenblatt William Griswold Jens Grossklags Svenja Hagenhoff Michael Haller Masahiro Hamasaki Raffay Hamid

Mike Hazas Chantel Hazlewood Jennifer Healey Sumi Helal

Urs Hengartner Steve Hodges

Jaap-Henk Hoepman

Jesse Hoey Eve Hoggan Paul Holleis Lars Erik Holmquist

Lars Erik Holmquist Gary Hsieh Polly Huang

Bret Hull
Masugi Inoue
Stephen Intille
Shamsi Iqbal
Sibren Isaacman
Giulio Jacucci
Lee Joonhwan
Wendy Ju
Gerrit Kahl
Eunsuk Kang
Ashish Kapoor
Stephan Karnischek

Stephan Karpischek Fahim Kawsar Judy Kay

Ashraf Khalil Danish Khan Sunyoung Kim Minkyong Kim Donnie Kim Jen King

Mikkel Baun Kjærgaard Predrag Klasnja

Andrew Ko Shin'ichi Konomi

Vassilis Kostakos

David Kotz
Sven Kratz
Christian Kray
John Krumm
Antonio Krüger
Tsvi Kuflik
Bob Kummerfeld
Kai Kunze
James Landay
Nicholas Lane
Marc Langheinrich
Eric Larson
Karin Leichtenstern

Jonathan Lester
Yang Li
Kevin Li
Lin Liao
Zhigang Liu
Clemens Lombriser

Hong Lu

Paul Lukowicz Markus Löchtefeld Julie Maitland Lena Mamykina Jennifer Mankoff Natalia Marmasse Nicolai Marquardt Sergio Matos Yutaka Matsuno Rene Mayrhofer

Alexander

David McDonald

Meschtscherjakov Florian Michahelles Daniel Michelis James Mickens Masateru Minami Anurag Mittal Iqbal Mohomed Mounir Mokhtari David Molyneaux Meredith Ringel Morris

Ann Morrison Floyd Mueller

Emerson Murphy-Hill

Mirco Musolesi Jörg Müller Tatsuo Nakajima Jin Nakazawa David Nguyen Petteri Nurmi Bashar Nuseibeh Eamonn O'Neill Daniel Olguin-Olguin

Patrick Olivier
Wei Tsang Ooi
Antti Oulasvirta
Joseph Paradiso
Chris Parnin
Kurt Partridge
Shwetak Patel
Sameer Patil
Don Patterson
Nick Pears

Thomas Pederson
Matthai Philipose
Andrew Phillips
Gian Pietro Picco
James Pierce
Zach Pousman
Bodhi Priyantha
Daniele Quercia
Ahmad Rahmati
Ramesh Ramadoss
Yvonne Rogers
Daniel Roggen

Stephanie Rosenthal Romain Rouvoy Dan Saffer Michele Sama

Shunsuke Saruwatari

## X Organization

Quan Sasaki Takeshi Sato Andreas Savvides Bernt Schiele Chris Schmandt Albrecht Schmidt Stacey Scott James Scott Peter Scupelli Julian Seifert Mubarak Shah Yi Shang Pravin Shankar Elaine Shi Josh Smith Timothy Sohn Frank Stajano Thomas Strang Leila Takayama

Yuri Takhteyev Poorna Talkad Sukumar Desney Tan Anthony Tang Karen Tang Nick Taylor Thiago Teixeira Bruce Thomas Andrea Thomaz Tammy Toscos Koji Tsukada Joe Tullio Keisuke Uehara Ersin Uzun Jan Van erp Kristof Van Laerhoven Alexander Varshavsky Jo Vermeulen

Nicolas Villar

Hongan Wang Evan Welbourne Kamin Whitehouse Stephen Whittaker Andy Wilson Jake Wobbrock Woontack Woo Oliver Woodman Michael Wright Kazuo Yano Koji Yatani Chuang-wen You Jaeseok Yun Lin Zhong Brian Ziebart John Zimmerman

## Table of Contents

## Practices with Smartphones Planning, Apps, and the High-End Smartphone: Exploring the Elizabeth Bales, Timothy Sohn, and Vidya Setlur Understanding Human-Smartphone Concerns: A Study of Battery 19 Denzil Ferreira, Anind K. Dey, and Vassilis Kostakos Sensing at Home, Sensing at Work Monitoring Residential Noise for Prospective Home Owners and Renters 34 Thomas Zimmerman and Christine Robson A Longitudinal Study of Pressure Sensing to Infer Real-World Water Usage Events in the Home ..... 50 Jon Froehlich, Eric Larson, Elliot Saba, Tim Campbell, Les Atlas, James Fogarty, and Shwetak Patel Exploring the Design Space for Situated Glyphs to Support Dynamic 70 Fahim Kawsar, Jo Vermeulen, Kevin Smith, Kris Luyten, and Gerd Kortuem Predicting the Future 79 John Krumm and A.J. Bernheim Brush *n*-Gram Geo-trace Modeling..... 97 Senaka Buthpitiya, Ying Zhang, Anind K. Dey, and Martin Griss Location Sensing Autonomous Construction of a WiFi Access Point Map Using Multidimensional Scaling ..... 115

Jahyoung Koo and Hojung Cha

Identifying Important Places in People's Lives from Cellular Network Data	133
Sibren Isaacman, Richard Becker, Ramón Cáceres, Stephen Kobourov, Margaret Martonosi, James Rowland, and Alexander Varshavsky	100
NextPlace: A Spatio-temporal Prediction Framework for Pervasive Systems	152
Augmenting Mobile Phone Use	
Using Decision-Theoretic Experience Sampling to Build Personalized Mobile Phone Interruption Models	170
SpeakerSense: Energy Efficient Unobtrusive Speaker Identification on Mobile Phones	188
Text Text Revolution: A Game That Improves Text Entry on Mobile Touchscreen Keyboards	206
Pervasive Computing in the Public Arena	
Pervasive Sensing to Model Political Opinions in Face-to-Face  Networks	214
Lessons from Touring a Location-Based Experience  Leif Oppermann, Martin Flintham, Stuart Reeves, Steve Benford, Chris Greenhalgh, Joe Marshall, Matt Adams, Ju Row Farr, and Nick Tandavanitj	232
Public Displays	
Hybrid Prototyping by Using Virtual and Miniature Simulation for Designing Spatial Interactive Information Systems	250