# Pervasive Intelligibility (PerInt 2012)
## *Workshop on Intelligibility and Control in Pervasive Computing*

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# Background and Motivation

The technological challenges outlined by Weiser's original vision of *ubiquitous computing* [18] are rapidly being overcome. However, core issues concerning the usability and user experience of ubicomp systems still remain to be solved. Interacting with ubicomp systems is very different from working with applications on a single (desktop) computer. Over the years, well-understood and proven heuristics and solutions have emerged for allowing end-users to understand and control their desktop computing environments. However, Bellotti et al. [3] state that these existing solutions are rarely adequate for — typically highly dynamic and adaptive —ubicomp environments.

Due to the proactive and complex behavior of ubicomp environments, it is especially important that systems are *intelligible* to allow users to understand "what the systems know, how they know it, and what they are doing" [4]. Additionally, systems should be *controllable* to let users recover when the system makes a mistake [4, 6, 7, 8, 9]. Previous studies have pointed out that users might become frustrated and lose trust in a ubicomp system when they are unable to understand or *control* it (e.g., [2]).

Researchers have been calling for the support of intelligibility and control for the past decade (*e.g.*, [2,4, 9], and even recently [10, 11]), and consequently researchers have provided tools and frameworks to support these requirements (e.g., [1, 8, 12, 16]), have looked into different user interfaces for intelligibility and control (*e.g.*, [7, 17]) , and studied the impact of intelligibility and control in ubicomp (*e.g.*, [5, 13, 14 , 15]). We would like to organize a workshop to bring together researchers active and interested in intelligibility and control to further develop and refine this body of work.

We believe the time is ripe for the ubicomp community to (i) formally identify user needs for intelligibility and control; build systems that are intelligible and user-controllable, supporting these systems through (ii) developing tools, toolkits, and architectures; and through (iii) developing design principles for building systems that allow users to scrutinize and inspect them for explanations on their state and functionality and control them henceforth. Users should be able to do so efficiently, efficaciously, and in a user-friendly manner. This requires (iv) appropriate evaluation criteria to judge whether ubicomp systems are sufficiently intelligible and users are given an adequate level of control.

The aim of the Pervasive Intelligibility workshop series is to bring together researchers from different backgrounds (*e.g.*, computer science, interaction design, ethnography, cognitive psychology, social sciences) to extract and extrapolate best practices for supporting intelligibility and to formulate a deeper understanding of intelligibility and user-centric controls for ubicomp systems. Our primary goals are to refine existing and identify new research directions for intelligibility and control issues in ubicomp systems; and to foster relationships for future collaboration. The first edition of this workshop (PerInt 2011) was organized in conjunction with Pervasive 2011.

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# Objectives

With this workshop, we seek to provide a forum for exchanging new ideas, prototypes, and insights about making ubicomp systems intelligible and controllable. We will bring together researchers from different backgrounds who are involved with the design and development of user interface and interaction techniques, system building, studies of user needs for intelligibility and control, and evaluation of existing use of intelligible and controllable ubicomp applications. Additionally, the workshop aims to provide hands-on experience with current state-of-the-art technology and prototypes through demonstration sessions.

Last year's "PerInt 2011" workshop investigated several topics regarding intelligibility and control based on the work presented by the participants, such as control over which information systems can forget, or how to provide intelligibility at the sensor level. After the introductions and research talks, participants formed small groups to brainstorm on specific research themes. Finally, each group presented their results to the other participants to start a broader discussion and gain further insights. The workshop made significant progress toward outlining the main challenges that need to be addressed and generated insights around specific research questions such as "How can we assess intelligibility?" Participants amongst others agreed that it is necessary to construct a theory of intelligibility based on existing HCI models and theories to support application designers, and suggested that educational comprehension tests might be a good way to assess the intelligibility of a system.

We plan to structure the workshop around four concrete agendas, building upon last year's results:

1. **Understanding *user needs* for intelligibility and control.** What should be explained in order to improve the intelligibility of a ubicomp system from an end-user perspective? What control mechanisms should be in place to ensure that users feel in control and trust the system? What is known about the interplay between intelligibility and control? Should control mechanisms be tuned to the type of intelligibility that systems provide? Which provisions for intelligibility and control should be available in all ubicomp systems, and which ones would depend on factors such as the usage context (*e.g.*, critical or urgent situations)? We are also interested in the ethnographic, cognitive psychological and social science theories underlying how people understand how applications work and seek to control them. These can help answer questions such as: What social factors influence what questions users ask? How do users ask questions? Why do users ask for certain types of explanations?

   **Expected outcome:** To create a taxonomy or framework of information and system states that lead to better intelligibility  and to define a set of concrete control constructs that should be addressed to facilitate end-user control in a ubicomp environment.

2. **Understanding *technical requirements* regarding intelligibility and control.** What can technically be explained or controlled? Is it feasible to explain the reasoning behind complex machine learning algorithms (*e.g.*, neural networks, Support Vector Machines)? If not, are there compromise explanations that would be sufficient? What level

of human control is attainable for these advanced algorithms? How can we allow developers to easily support intelligibility or control in their applications? Is it possible to balance the trade-off between better intelligibility or control and an increase in development effort?

**Expected Outcome:** To categorize current practices in building ubicomp architectures or toolkits that expose their application logic for better understanding and control, and use this categorization as a basis to identify gaps in existing approaches. Additionally, we would like to gain more insight into how machine learning algorithms can be adapted so that they can explain their internal workings and allow users to control certain aspects of their behavior.

3. **Investigating the *design space of user interfaces* and *interaction techniques* for intelligibility and control.** How can we effectively explain to users how a ubicomp system works? How can non-technical and non-expert users be enabled to configure, personalize and correct their environment's behavior? In situations where no display is available (*e.g.,* tangibles), where the available screen estate is limited (*e.g.,* mobile devices, wearables), or where users' visual attention is required elsewhere (*e.g.,* driving a car), it might be necessary to provide intelligibility through other modalities such as sound or touch.

   **Expected Outcome:** To provide an overview of the current state of the art in user interfaces and interaction techniques for intelligibility and control, as well as develop ideas for novel user interfaces. With this discussion, we hope to contribute a set of design guidelines for intelligibility and control user interfaces.

4. **Defining a set of *evaluation criteria* for judging whether a system is sufficiently intelligible and puts enough power in the user's hands.** What do we expect will change when systems add support for intelligibility and control? How do we measure vague criteria such as trust or understanding? Although evaluation criteria such as effectiveness, subjective satisfaction, understanding or trust might seem to be logical choices, it is currently not clear whether these criteria are appropriate or if there other measures which are better suited. Would it be possible to incorporate educational techniques that assess students' comprehension to assess a system's intelligibility? Moreover, it is necessary to determine how and under what conditions these evaluations should be performed (*e.g.*, lab studies are unlikely to be sufficient).

   **Expected outcome:** To identify a set of measures and evaluation strategies that can be used to effectively evaluate a ubicomp system's support for intelligibility or control.

We hope these four themes will provide a solid base for formulating future research directions and case studies for research on intelligibility and user-centric control in ubicomp.

We plan to prepare a poster for the Pervasive 2012 conference, co-authored by the workshop participants, as well as an article in a magazine (*e.g.*, IEEE Pervasive) that defines future spaces for intelligibility research with a set of research challenges that were defined during the workshop.

# Workshop Format and Activities (Expected Agenda)

We propose a one-day workshop of 6 working hours, excluding the breaks. Our aim is not to serve as an extensive mini-track to the main conference, since we seek to facilitate discussions more than lecture presentations. Our objective is to define a number on concrete research directions through structured discussions, collaborative brain storming in parallel to hands-on design tasks. Accordingly, we would like to divide the workshop activities into 4 sessions:

**Introductions and Oral Presentations** (*Early Morning*): We would encourage participants to read up the papers of accepted submissions before attending the workshop to expedite discussions of the material. In this session, we start with all participants introducing themselves and briefly describing the relevant research that they do. We then have a "*madness session*" where authors present their papers in a vibrant and fast-paced style, to ensure we assign most of our time to discussions and interactive activities, rather than lectures. The madness session is followed by a round-table discussion of questions, comments and issues raised from the presentations.

**Break and Demonstrations (30 min).** We would like to take advantage of the first break to allow participants (and organizers) to demonstrate their work. This way, participants can get hands-on experience with, and discuss current state-of-the-art technology and prototypes.

**Breakout Session 1 – Topical Discussions** (*Late Morning*). Participants will be divided into areas of expertise along our four themes. Each group would discuss existing work done in the area, current gaps in research, and opportunities for future work. Discussions may involve activities such as brainstorming exercises, drawing storyboards and building physical design mockups.  At the end of the breakout session, each group would present their findings ($\sim$5-10 min per group). This would help give all participants clearer views of what is happening in the various aspects of research in intelligibility and control in ubicomp.

**Lunch (1 hour).**

**Breakout Session 2 – Integration Discussions** (*Early Afternoon*). The aim of this session is to facilitate cross-disciplinary pollination of ideas from the four themes. We will shuffle participants with expertise spanning the four themes into three groups. Each group would focus on a canonical application domain (*e.g.*, healthcare, smart homes, mobile services) and discuss user issues and requirements, technical and design solutions, and evaluation strategies for each domain topic.

**Break and Networking (40 min).** This break session is deliberately longer to allow participants to strike up productive discussions with individuals they may be interested in future collaborations with.

**Wrap Up** (*Late Afternoon*): Each group will be invited to present and discuss their results of the second breakout session with the rest of the workshop participants. Afterwards, we will discuss possible collaborations, make plans for future editions of the workshop and ask participants for their feedback.

As mentioned before, we aim to summarize the outcome of the workshop discussions in a *poster* for the Pervasive 2012 conference, co-authored by the workshop participants.

**After the Workshop**

Materials produced during the workshop (*e.g.*, the poster, slides from the breakout sessions) will be posted on the workshop web site at *http://research.edm.uhasselt.be/~pervasive-intelligibility/*. We will continue to maintain the site to serve both the participants and the broader community developing around this topic.

In addition to the Pervasive 2012 poster submission, we intend to communicate the results of the workshop to the larger ubicomp community by submitting an article to a magazine (*e.g.*, IEEE Pervasive). In this article, we hope to define future spaces for intelligibility research with a set of research challenges that were identified in the workshop.

If the papers and workshop discussion reflect sufficient progress and cohesiveness, we will also work toward producing a special issue of a journal (*e.g.*, Personal and Ubiquitous Computing) or possibly an edited book.

# Solliciting Submissions

We will solicit both *position papers* and *research papers* describing high quality and previously unpublished research results on intelligibility and end-user control for ubicomp.

***Position statements*** may be up to 2 pages. They should outline a person's interest and experience in the topic of the workshop. Position statements will not be included in the proceedings but will serve as introductions for discussions.

***Research contributions*** introducing novel concepts and presenting new insights may be between 4-6 pages. These submissions can discuss experiences and lessons learned from applying intelligibility and control in the real world, as well as new tools, applications, user interfaces and interaction techniques to support intelligibility and control in ubicomp  environments.

Areas of interest include, but are not limited to:
- User studies of ubicomp systems and experience reports addressing end-user needs and discussing issues of intelligibility and control.
- Ethnographic, cognitive psychological, or social science studies about how users understand and seek to control ubicomp systems and applications
- Programming techniques (*e.g.,* design patterns, models), algorithms, architectures, toolkits and tools to support intelligibility and control, including work on how machine learning algorithms can be made intelligible and controllable, techniques to explain and configure ubicomp architectures, and tools for end-user programming.
- Interaction techniques and user interfaces to support intelligibility and control, including solutions for challenging interaction contexts (*e.g.,* tangibles, wearables, in-car user interfaces) that might require the use of different modalities; and design guidelines or frameworks for intelligibility and control.
- Information visualization techniques to help users better interpret explanations from ubicomp systems and better understand how they can control them.
- Novel applications and prototypes demonstrating the implementation and implications of intelligibility and control.

- Evaluation criteria and methods to assess support for intelligibility and control in ubicomp systems.

**Promoting the Workshop**

In addition to being listed on the Pervasive 2012 website, we will announce the Call for Participation at popular mailing lists and calendars (*e.g.,* ACM, CHI-announcements, Interaction-Design.org, WikiCfp) and other fora such as social networking websites (*e.g.,* Twitter, Facebook). Workshop flyers will be distributed at related conferences and workshops that take place before Pervasive 2012.

Furthermore, we will directly contact researchers and practitioners who are likely to be interested in the workshop and write to relevant institutions, projects or activities. We will continue our efforts of promoting the workshop and getting in touch with potential participants during the period leading up to the workshop deadline. We refer to the section on selecting participants for the list of potential participants. As mentioned before, the call for participation will solicit both *position statements* and *research papers* that address the topics of interest.

A web site will be set up before the workshop at *http://research.edm.uhasselt.be/~pervasive-intelligibility/*. All selected papers will be made available to the participants on this site, along with other details about the workshop. The web site will be maintained to help the participants and this emerging community to keep in touch.

## <u>Selecting Participants</u>

We expect to bring together **15-20 participants** from academia and industries who are working in intelligibility and control and in related areas. Participants will be selected based on the submission of the research and position papers. The organizers and the international program committee will review the submitted papers to select the participants.  In addition to an open Call for Participation, the organizers will also personally invite researchers to submit their work and participate in the workshop.

**Program Committee**

The preliminary list of the program committee (some confirmations are still pending) includes:

- Margaret Burnet (Oregon State University, USA)
- Karin Coninx (Hasselt University, Belgium)
- Joëlle Coutaz (Université Joseph Fourier, France)
- Anind K. Dey (Carnegie Mellon University, USA)
- Hans Gellersen (Lancaster University, UK)
- Judy Kay (University of Sydney, Australia)
- Kris Luyten (Hasselt University, Belgium)
- Tatsuo Nakajima (Waseda University, Japan)
- Mark W. Newman (University of Michigan, USA)
- Antti Oulasvirta (HIIT, Finland)
- Aaron Quigley (University of St. Andrews, UK)
- Albrecht Schmidt (University of Stuttgart, Germany)
- Elise van den Hoven (Eindhoven University of Technology, The Netherlands)
- Hide Tokuda (Keio University, Japan)

# Organizers

**Jo Vermeulen** is a PhD student and teaching assistant at the Expertise Centre for Digital Media (EDM), a research institute of Hasselt University in Belgium. His research interests lie at the intersection of Human-Computer Interaction and Ubiquitous Computing. More specifically, he is investigating techniques that help users to understand what is happening in their Ubicomp environment and that allow them to intervene if necessary.

http://www.jozilla.net/

**Brian Y. Lim** is a Ph.D. student in the Human-Computer Interaction Institute (HCII) at Carnegie Mellon University working with Anind Dey. His research interests are in ubiquitous computing, context-aware applications. His current research looks at how to make context-aware applications intelligible, so that they can explain how they function, and users would find their behavior more believable, and find them more usable.

http://www.brianlim.net/

**Fahim Kawsar** is a Senior Application Researcher at the Ambient Media Department of Bell Labs, Belgium. From 2004-9, he was at Waseda University in Japan for postgraduate studies (MEng in 2006, PhD in 2009), and from 2004-6 also at Nokia Research Center Tokyo. His research revolves around pervasive computing with a specific focus on Internet of Things, End User Programming, Novel Interaction Techniques, and User Experience Engineering. He's a former Microsoft Research fellow and a member of the IEEE and the ACM.

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