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Abstract

In this workshop, we will review and discuss challenges and opportunities for HCI in relation to cross-surface interaction in the wild based on the bring-your-own-device (BYOD) practice. We aim to bring together researchers and practitioners working on technical infrastructures for cross-surface computing, studies of cross-surface computing in particular domains as well as interaction challenges for introducing cross-surface computing in the wild, all with a particular focus on BYOD. Examples of application domains are: cultural institutions, work places, public libraries, schools and education.

Keywords

Cross-surface interaction, BYOD, ubicomp ecologies, multi-surface interactions, multi-device interactions, spatial reconfigurations of displays, spatially distributed interfaces, multi-screen workplaces, wearable devices.

ACM Classification Keywords

H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

Background

People already carry highly interactive, networked and general-purpose personal devices (such as phones, watches, tablets, laptop computers and even head-mounted displays) around with them wherever they go and use these for everyday activities; work, leisure, learning, tracking, socialising, communicating, consuming and everything in between. Through these activities, people develop a tailored personal ecology of devices [1], applications and services, and a familiarity that spans devices and applications. Rather than being forced to use particular applications and devices, people want and expect to be able to use their personal devices and the familiarity with other systems in their everyday activities. Using personal devices as mediators for interaction offers a great potential for developing cross-surface[1] systems and applications based on 'bring your own device' (BYOD) in the wild; e.g. in the school class, the public library or at the workplace[2].

Prior work has introduced a wide range of techniques and infrastructures to facilitate cross-surface interaction. These include sensing of nearby devices [11,12] device pairing [6,8,13,15], information exchange [12,15] and configuration of cross-device ecologies [7].

Despite the success of these approaches, many cross-surface interaction techniques and systems require advanced sensing and infrastructure, which are impractical in real-world scenarios outside of the lab. There are still fundamental challenges that prevent the full potential of cross-surface interactions with personal devices in the wild. Workplace and field studies (e.g., [3,10]) highlight these issues, revealing how users struggle with how devices can communicate, what content can be exchanged, how to opt-out from connecting devices together [5], how to configure devices to cooperate in one seamless workspace, and with the social frictions introduced by using personal devices as mediators in the wild [2].

We need a better understanding of the different possible manifestations of BYOD based cross-surface interaction, their advantages and disadvantages, of how to support cross-surface interaction in the wild, in terms of technologies, real-world use cases, utilizing individual familiarity, expectations and making sense of the available interactions and their impact on human activities. This workshop is the second instalment in a series of workshops around interacting with multi-device ecologies in the wild. The first edition was organized at ACM ITS 2015 [9].

Objectives

The objective of this workshop is to map opportunities and challenges from the perspective of researchers and practitioners derived from the participants' experiences in designing, building and studying systems in and for the wild. The opportunities and challenges will be organized around four themes:

Applications and use cases

What are the use cases and application domains for BYOD based cross-surface interaction? Which concrete challenges do these pose (e.g. public vs. private settings) and which type of device configurations do they

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[1] Also referred to as multi-device, multi-surface or cross-device.

[2] The term originates within corporate IT-departments. According to Forrester [18] BYOD has a positive impact on productivity, but in general it is seen as a challenge to data security, infrastructure and IT-management in general (see [16]).

afford or provide (personal device to personal device, or inclusion of stationary shared surfaces)?

Expectations and familiarity

How can we make use of people's familiarity with a range of devices and applications? What role does initial motivation and expectation play when potential users encounter cross-surface systems? How can we support different levels of familiarity and use knowledge associated with the personal ecology in the development of cross-surface systems?

Beyond interaction techniques

How do people make sense of the interplay between their personal device and the surrounding cross-surface ecology? How can we support discoverability and learnability of interactions, inform users of action possibilities and provide feedback about cross-surface connections? How can users configure cross-surface setups that support their activities?

Technological infrastructure

Which enabling technologies are needed to allow users to bring their personal devices to participate in multi-surface interaction. How can these technologies be deployed, democratized and shared with a broader audience? What are the major current technological stopping blocks in supporting seamless cross-surface interaction with personal devices?

Relation to Other Initiatives and the Larger Research Community

This workshop will be the second workshop under the Cross-Surface title. The first was held at ACM Interactive Tabletops and Surfaces in November 2015 and is entitled "Cross-Surface: Workshop on Interacting with Multi-Device Ecologies in the Wild" [9]. In this second workshop we focus the scope to BYOD based systems and use cases, which has gained a strong interest in the cross-surface/cross-device systems community in recent years.

Organizers

Steven Houben *is a Research Associate at University College London. He works at the Intel Collaborative Research Institute on Sustainable and Connected Cities (ICRI-Cities) and UCL Interaction Centre on projects related to multi-device environments, physical computing and sensor-based systems.*

Jo Vermeulen *is a Postdoctoral Fellow in the InnoVis group at the Interactions Lab at the University of Calgary. Previously, he was a Research Fellow at the HCI Centre at the University of Birmingham. He is interested in addressing interaction challenges within ubicomp spaces, including providing intelligibility, discoverability, feedback and feedforward for cross-device interactions.*

Clemens Klokmose *is a Post Doc at the Computer Science department at Aarhus University and is associated with the center for Participatory Information Technology. His main interest is human-computer interaction that goes beyond personal computing.*

Nicolai Marquardt *is a Lecturer (Assistant Professor) in Physical Computing at the University College London. At the UCL Interaction Centre he works on projects in the research areas of ubiquitous computing, interactive surfaces, sensor-based systems, prototyping toolkits, and physical user interfaces.*

Johannes Schöning *is Professor of computer science at Hasselt University working at the Expertise centre for Digital Media (EDM). His main research interests lie at the intersection between human-computer interaction (HCI), geographic information science and ubiquitous interface technologies.*

Harald Reiterer *is Professor at the Computer and Information Science Department of the University of Konstanz. His main research interests include different fields of Human-Computer Interaction, like Interaction Design, Usability Engineering, and Information Visualization.*

Mario Schreiner *is a PhD student at the Human-Computer Interaction Group at the University of Konstanz. His focus is on cross-device interaction with both mobile and traditional devices, in particular for ad hoc and in the wild settings.*

Henrik Korsgaard *is a PhD student at the Computer Science department at Aarhus University and is associated with the center for Participatory Information Technology. His main interest is in place-specific computing and ubiquitous computing that focuses on computer mediated localized interaction and participation.*

Pre-Workshop Plans

Participants
We aim to bring together 15–20 participants from academia and industry that are working on cross-surface systems and related areas. In addition to an open Call for Participation, the organizers will personally invite researchers to submit their work and participate in the workshop. Participants will be selected by the organizers based on the submitted position papers and their relevance to the scope and goal of the workshop. We

aim to gather a multi-disciplinary group of participants consisting of academic researchers, designers and practitioners from industry. Accepted workshop papers will be distributed among participants before the workshop and published on the workshop website.

Website and Advertising the Workshop
Our website for the previous Cross-Surface workshop (http://www.cross-surface.com/) will be repurposed as a portal for this, previous and future workshops. We will distribute a call for position papers in all relevant communities. In addition to being listed on the CHI 2016 website, we will announce the Call for Participation at popular mailing lists and calendars (e.g., ACM, CHI-announcements, Interaction-Design.org, WikiCFP) and social media (e.g., Twitter, Facebook). Workshop flyers will be distributed at related conferences and workshops that take place before CHI 2016, including our own Cross-Surface workshop at ITS 2015. The calls will be posted on the workshop website, along with other details about the workshop. 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.

Soliciting Submissions
We will solicit position papers of up to 4 pages in the ACM SIGCHI Extended Abstract format that describe original research and outline a person's interest and experience in the topic of the workshop. Selected papers will serve as introductions for discussions and will be made available to the participants on the workshop

website. Submissions will be juried by the organizing committee based on originality and relevance.

Workshop Structure

At the workshop
We propose a one-day, 8-hour workshop. The workshop will be a combination of discussions and analytical activities in groups of 4 or 5 people.

1. Preparation before the workshop
We will ask participants to read the accepted position papers, together with a short digest of the outcome of the previous Cross-Surface workshop that we will circulate.

2. Kick-off madness and keynote
We will kick off the workshop by asking all participants to introduce themselves and their position paper in a 1-minute madness presentation. We will ask each participant to end by stating one great potential of and one grand challenge to BYOD based multi-surface interaction. After the kick-off, Professor Susanne Bødker will give a keynote on using personal devices as mediators for interaction in the wild.

3. *Case study*
Participants will form groups based on selecting one of four (fictional) case studies presented by the organizers. The case studies will be derived from participants' submissions and related work, and include a description of the application domain and a problem being addressed. An example of a case study could be collaborative web search in a high-school social science class (as inspired by [15]). Each group will now go through a process inspired by future workshops [13] which includes a critique phase (what are the current prob-

lems?), a visionary phase (how would this ideally be supported by cross-surface interaction?) and finally an implementation or realization phase (what are the challenges in realizing the visions? What technologies could be involved? What are the social-technical implications/challenges?). The groups will be asked to summarize their analysis on an A1 poster.

4. Poster presentations
After lunch each group will have 30 minutes allocated for presenting their analysis and we will discuss it in plenary. The last 5-8 minutes of each session will be spent on deriving the core potentials and challenges for BYOD based multi-surface interaction from the given analysis of the case study.

5. Group reflections and panel
As a final outcome, we will create a large collage/map visualizing the derived potentials and challenges for BYOD cross-surface interaction and how they can structure future research in the field. We will have a small panel consisting of members of the organizing committee, the keynote speaker and invited guests to discuss the outcome of the workshop.

After the Workshop
Materials produced during the workshop will be posted on the workshop web site (http://www.cross-surface.com/). We will continue to maintain the site to serve both the participants and the broader community developing around this topic.

Pre-Workshop Plans
The results of the workshop together with the results of the previous Cross-Surface workshop will be communicated to the larger HCI community by submitting an

article to a magazine (e.g., *ACM interactions*). In this article, we hope to define future design spaces for cross-surface interactions.

Time	Activity
09:00	Introduction to the workshop
09:15	Keynote by Professor Susanne Bødker
10:00	Paper presentations
10:30	Coffee break
11:00	Case studies and brainstorm
13:00	Lunch
14:00	Present ideas + map out design space
16:00	Coffee break
16:30	Group reflections and panel
17:30	Close

Figure 1 Timeline of the workshop

We will also invite all workshop participants to submit an extended article of their submission for a special issue on "*Interaction with Device Ecologies in the Wild*" in the Personal and Ubiquitous Computing journal that will appear end of 2016. This information and call for papers will also be shared on the http://www.cross-surface.com/ website and will be open to other interested researchers in the community.

Call for Participation

People are increasingly carrying highly interactive, networked, personal devices (e.g., phones, tablets, laptop computers) around for both work and leisure. This offers great potential for cross-surface applications where you 'bring your own device' (BYOD); e.g. in school, libraries or at the workplace. Prior work has introduced a wide range of cross-surface techniques, such as sensing of nearby devices, device pairing, information exchange and configuration of cross-device ecologies.

Despite the success of these approaches, they often require advanced sensing and infrastructure, which are impractical in real-world scenarios. There are still fundamental challenges that prevent cross-surface interaction in the wild, such as technical infrastructure, interaction techniques, and social context.

The objective of this workshop is to chart the potentials and challenges of BYOD-based multi-surface interaction, including distributed interfaces, multi-screen workspaces, ad-hoc connectivity and wearable displays.

We solicit position papers of up to 4 pages in the ACM Extended Abstracts Format that describe original research and outline a person's interest and experience in the workshop topic. Supplementary material can be submitted. Submissions will be juried by the organizing committee based on originality and relevance and selected papers will be made available on the workshop website beforehand. Contributions must be submitted by 21st of December, 2015. Participants will be invited to submit an extended full article of their submission for a special issue on "Interaction with Device Ecologies in the Wild" in the Personal and Ubiquitous Computing journal that will appear late 2016.

References
1. Bødker, S., & Klokmose, C. N. (2012). Dynamics in artifact ecologies. In *Proceedings of the 7th Nordic Conference on Human-Computer Interaction: Making Sense Through Design* (pp. 448-457). ACM.

2. Bødker, S., Klokmose, C. N., Korn, M., & Polli, A. M. (2014, October). Participatory IT in semi-public spac-

es. In *Proceedings of the 8th Nordic Conference on Human-Computer Interaction: Fun, Fast, Foundational* (pp. 765-774). ACM.

3. Dearman, David, and Jeffery S. Pierce. "It's on my other computer!: computing with multiple devices." *Proc. Of CHI'08.* ACM.

4. Ghosh, A., Gajar, P. K., & Rai, S. (2013). Bring your own device (BYOD): Security risks and mitigating strategies. *Journal of Global Research in Computer Science*, *4*(4), 62-70.

5. Greenberg, Saul, Boring, Sebastian, Vermeulen, Jo and Dostal, Jakub. "Dark Patterns in Proxemic Interactions: A Critical Perspective." *Proc. of DIS '14*. ACM.

6. Hinckley, Ken. "Synchronous gestures for multiple persons and computers." *Proc. UIST '03*. ACM.

7. Houben, Steven, Paolo Tell, and Jakob E. Bardram. "ActivitySpace: Managing Device Ecologies in an Activity-Centric Configuration Space." *Proc. ITS '14*. ACM.

8. Houben, Steven, and Nicolai Marquardt. "WatchConnect: A Toolkit for Prototyping Smartwatch-Centric Cross-Device Applications." *Proc. CHI'15.* ACM, 2015.

9. Houben, Steven, Vermeulen, Jo, Klokmose, Clemens, Marquardt, Nicolai, Schöning, Johannes, and Reiterer, Harald. Cross-Surface: Workshop on Interacting with Multi-Device Ecologies in the Wild. In *Proc. ITS '15*. ACM, 485-489.
    http://dx.doi.org/10.1145/2817721.2835067

10. Jokela, Tero, Jarno Ojala, and Thomas Olsson. "A Diary Study on Combining Multiple Information Devices in Everyday Activities and Tasks." *Proc. CHI '15*. ACM, 2015.

11. Kortuem, Gerd, Christian Kray, and Hans Gellersen. "Sensing and visualizing spatial relations of mobile devices." *Proc UIST '05*. ACM.

12. Marquardt, Nicolai, Till Ballendat, Sebastian Boring, Saul Greenberg, and Ken Hinckley "Gradual engagement: facilitating information exchange between digital devices as a function of proximity." *Proc. ITS '12*. ACM.

13. Mayrhofer, Rene, and Hans Gellersen. "Shake well before use: Authentication based on accelerometer data." Pervasive computing. Springer Berlin Heidelberg, 2007. pp. 144-161.

14. Müllert, N., Jungk, R., & Institute for Social Inventions, London (United Kingdom);. (1987). Future Workshops: How to create desirable futures. *London, United Kingdom: Institute for Social Inventions, London (United Kingdom)*.

15. Rädle, Roman, Hans-Christian Jetter, Nicolai Marquardt, Harald Reiterer, and Yvonne Roger. "HuddleLamp: Spatially-Aware Mobile Displays for Ad-hoc Around-the-Table Collaboration." *Proc. ITS '14*. ACM.

16. Rädle, R., Jetter, H. C., & Reiterer, H. (2013). *TwisterSearch: A distributed user interface for collaborative Web search* (pp. 53-67). Springer London.