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Socio-technical Design of Ubiquitous Computing Systems

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Foreword

The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it.

Mark Weiser

What was still an ardent vision in the early 1990s—when Mark Weiser drew his picture of the computer for the twenty-first century[1]—has now become reality. Progress in information technology has increasingly turned computing into that "integral, invisible part of people's lives" that Weiser prophesied. Ubiquitous Computing (UC) has arrived. It enables a new level of information processing. Using sensor data, UC-based systems detect their current usage context. They automatically adapt their services to the user's situational needs and interact with UC services or resources in their environment on an ad hoc basis.

So did Mark Weiser's prophecy fulfill? Yes and No. With the UC paradigm computers are "disappearing" from their users' attention. Users are indeed *freed* from having to bother about computers. Yet what Weiser did not foresee: gaining convenience and freedom is at the same time exposing our freedom to new hazards. At the beginning of the twenty-first century, concerned voices about information technology are increasingly heard. Are we still the masters of our technological servants, or do we surrender power to our smart devices? Are we still the masters of our own lives, or who else can follow and possibly abuse the information that is collected and processed by UC-systems without us even being aware of it?

In the light of these apparently conflicting challenges, researchers at the Interdisciplinary Research Center for Information System Design (ITeG) at the University of Kassel set out to address ubiquitous computing from a socio-technical perspective in 2010. They initiated the research cluster VENUS (Design of socio-technical

[1] Weiser, M.: The Computer for the twenty-first Century. Scientific American (9), 94–104 (1991), p. 94.

integration in context-aware ubiquitous systems), which has been funded from 2010 to 2013 by the federal state of Hesse within its LOEWE programme for promoting cutting-edge research. VENUS has brought together researchers from different fields such as computer science, information systems, human–computer interaction, and law who seek to find general principles and guidelines for the design of socially responsible UC systems.

Designing self-adaptive, context-aware, and knowledge-processing systems is by itself a formidable challenge. The VENUS team further raised the bar with their objective to permanently think about UC from multiple perspectives. System usability, user trust in the technology, and adherence to privacy laws and regulations were discovered as particularly important criteria for UC design. To gain user acceptance, technology has to be integrated into the individual user's actions. It has to support her (or him) in accomplishing personal tasks and in cooperating with others. In addition, UC systems need to be integrated into society to be of practical use. Their features should be available at any time and place. Achieving all these types of integration is a key success factor for the new technology.

From the outset, the guiding principle of the VENUS team was to improve the social integration of UC technology. In 4 years of intensive interdisciplinary work the team has developed an encompassing blueprint for systematic, interdisciplinary software development. The VENUS design concept covers the particular functional and nonfunctional design aspects of ubiquitous computing at the interface between technology and human beings.

Core results of the VENUS project are presented in this volume. Their message is highly encouraging. There is no need to take away from the enthusiasm for ubiquitous computing expressed by Mark Weiser. To the contrary, if we learn to switch perspectives and understand that UC features such as disappearing to invisibility can have positive as well as negative aspects, and hence, if we also implement the *option* for visibility, we can be confident to remain the masters of our technological servants, no matter what technological progress will lead to. The lessons from this volume are important for researchers as well as for society in general. As the head of Advisory Board for the ITeG center, I hope that the volume will find the broad interest and the diverse audience it deserves.

Stuttgart, Germany Paul J. Kühn
December 2013

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Part I
Introduction

Chapter 1
A Research Agenda for the Socio-Technical Design of Ubiquitous Computing Systems

Kurt Geihs and Holger Hoffmann

Abstract While technologies make Ubiquitous Computing a reality today, proper engineering methods for creating successful systems are still lacking or inadequate. The result is that mere "trial-and-error" approaches are used when developing novel UC systems. In this chapter we present an overview over the major development challenges, focussing on both social as well as technical aspects of UC system development. These range from the embedding of systems into a social context, sensing and adapting to different usage context and emergent system properties to the need for multidisciplinary cooperation during system development. Furthermore we analyse existing socio-technical development approaches from literature and their shortcomings in relation to the development challenges before introducing the VENUS research approach. We conclude this chapter by giving an outlook for the application of the VENUS research results and chances for further research.

1.1 Introduction

With the advances of technology in recent years, especially the development of mobile devices and pervasive applications, the vision of Ubiquitous Computing (UC) as described by Weiser [71] almost 25 years ago is a reality today. In a nutshell, UC is a computing concept where computing is taking place around us while the computing devices are made effectively invisible. Especially the recent

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increase in smartphones and the multitude of pervasive applications for all aspects of personal as well as professional life result in technology that is "interwoven into the fabric of everyday life" [71]. This new level of proximity between users and computers holds the potential to combine the users' high level cognitive capabilities and creativity with the computers' interconnectedness and ability for high speed data processing—a symbiosis likely to become transformative in many different application domains [9].

However, the development of UC systems faces numerous challenges. Engineering methods and tools for creating successful systems are still lacking. Bernstein et al. [9] argue that most applications are built using mere "trial-and-error" approaches and research and practice only have a frail understanding of why most of them still fail. They come to the conclusion that in the future, developers of such systems will have to exceed the traditional role as software architects who implement algorithms and also incorporate organisational and societal aspects into system development. This premise brings to mind the socio-technical systems paradigm, which was first mentioned in 1951 by Trist and Bamforth [67] in a work-related context. In the traditional socio-technical perspective, e.g. found in [12, 13, 50], the technical perspective is often condensed to a minimum. Baxter and Sommerville [7, 64] however describe a more holistic approach in which the balance between social/behavioural aspects of system development are matched with technical aspects of system development.

This book presents the results of the VENUS project. VENUS is an research cluster at the Interdisciplinary Research Center for Information System Design (ITeG) at Kassel University, funded by the State of Hesse as part of its LOEWE initiative to foster excellence in research and development.[1] The long-term goal of VENUS is the definition and evaluation of a comprehensive interdisciplinary development methodology for the design of socially aware UC systems. In particular, VENUS focuses on the interactions between the new technology, the individual user and the society. Therefore, four disciplines are represented in VENUS, i.e. computer science, information systems, human-computer interaction, and law, contributing to the research of development methods and tools for ubiquitous applications and taking into account theories, methods and tools described in the context of socio-technical system design.

The following chapters of this book will show how VENUS has responded to these challenges. In this first chapter we give an overview over the research strategy of VENUS and the common challenges that developers face when creating ubiquitous applications, and we discuss the current state of the art of socio-technical system design.

[1] https://hmwk.hessen.de/loewe.