

# Next Generation Intelligent Environments



Tobias Heinroth • Wolfgang Minker  
Editors

# Next Generation Intelligent Environments

Ambient Adaptive Systems

 Springer

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# Foreword I

Recent advances in Intelligent Environments research give a glimpse into the future of our planet and reveal exciting visions of smart everything – smart cities, smart homes, smart workplaces, smart hotels, smart schools, and much more. Driven by technological evolution offering low power many-things and wireless almost-everything (e.g., IEEE 802.15.4 radio, wireless sensor networks, sensor platforms), we could, in only a decade, envision and prototype impressive cyber-physical systems and applications. In most of these systems, the goal has been clear and convincing, and the technology proved to be promising and exciting.

But prototyping is only a beginning, and much remains to be innovated and done before such Intelligent Environments (IE) become common places. Many research disciplines must collaborate among and within themselves, including domain experts (of the particular environment, e.g., gerontologist for assisted living spaces), behaviour scientists, engineers, computer scientists, to mention just a few. Collaboration within the computer science and engineering discipline is key to the success of IE. Systems support and middleware are essential foundation to building any systems – IE are no exception. Software engineering is urgently needed to understand and support the full life-cycle of IE. New programming models are also needed for developing safe and adaptive applications and services. New notions of trust must be formulated and supported to ensure symbiotic relationship between the users and their environments. Understanding human computer interaction is crucial and in some environments, affecting persuasion is of paramount importance. But this is not all. Without machine learning and computational intelligence techniques, the potential utility and “ceiling of goals” of IE would be severely limited.

“Next Generation Intelligent Environments” provides an excellent compendium of collaborative research efforts in support of *ambient ecologies* orchestrated within a mega project funded by the European Community – The Adaptive and TRusted Ambient eCOlogies (ATRACO).

The book goes beyond prototypes and addresses the fundamental generalities and necessary ecologies that can lead to better design, development, operation and adaptation of IE. The book covers many important areas of collaborative research within computer science and engineering, including system support and middle-

ware, applied knowledge and ontology, user interactions, artificial intelligence, user experience and much more. The coverage is unique in that all chapters are inter-related and aligned, showing key dependencies and themes. One overarching theme is adaptation that appears in many chapters addressing the environment itself as well as the user and their interactions.

It is gratifying to finally see a book contributed to the IE research community that brings unprecedented depth in the treatment of such delicately interdependent topics that make up the core areas of IE. It is a timely and a much needed contribution that will help shape the curricula in emerging smart systems specialities and programs around the world.

Gainesville (USA), February 2011

*Sumi Helal*

## Foreword II

Technological advances have been shaping our world for centuries. The belief that technology is beneficial to human kind has deep roots in our societies, since initial technological developments were closely linked to survival conditions like hunting and building. Nowadays technology is around us everywhere and the lives of most of humanity have become closely intertwined with more or less intensity.

Many western societies are at this point in history investing on technology that can pervade all levels of daily life to assist humans in their activities, whether this is at home, at the office, at school or shopping. The idea is that there is technology already available that can help identifying some situations where humans need help and also to deliver some of that assistance, in a more or less automated way. This has led to the idea that we can create “Intelligent Environments” which can actively pursue benefits for the humans who inhabits those environments.

This is no trivial enterprise. Technology can fail. Humans are complex beings. We live in a dynamic world and situations can change substantially in short periods of time. The engineering of such systems require the careful blending of cutting edge technology and expertise. Previous advances in Computer Science, Engineering, Architecture, Social Sciences and other areas are supporting the development of a new generation of technological developments which are aiming at helping you wherever you are. So far humans have to invest substantial effort to understand how to interact with a computer and benefit from it. This technology aims at bringing benefits to human without demanding a specific technological expertise from the human.

The advances provided by the ATRACO project are a good example of a well rounded solution which provides a dynamic middleware and adaptive networking architecture which can facilitates the creation of Intelligent Environments making available a dynamic range of services. Intelligent adaptation of the environment and flexible interaction with humans complete a technological solution which adapts to context and situations to be most useful. Another important contribution of this project is that these technological advances are designed with ethical principles in mind.

Surely this will not be the last word in the area. Humans seem to have developed an insatiable appetite for technological developments that can potentially make their lives easier. Whether you just become interested on doing serious work in this area or you want to keep yourself updated in the latest developments that help you to design the world of tomorrow this book is a good place to start to get engaged with this development which can shape our world.

Jordanstown (UK), February 2011

*Juan Carlos Augusto*



# Preface

This book is based on the work that has been conducted within the ATRACO (Adaptive and TRusted Ambient eCOlogies) project<sup>1</sup> as part of the European Community's 7th Framework Programme (FP7/2007-2013) under grant agreement n° 216837. The aim of ATRACO project is to contribute to the realization of trusted ambient ecologies. Interactive appliances, collaborative devices, and context aware artefacts, as well as models, services, software components are parts of ambient ecologies. A context-aware artefact, appliance or device uses sensors to perceive its context of operation and applies an ontology to interpret this context. It also uses internal trust models and fuzzy decision making mechanisms to adapt its operation to changing context. Finally, it employs adaptive dialogue models to communicate its state and interact with people.

Ambient ecologies form the infrastructure that supports user activities. In ATRACO, each activity is modelled as a “bubble” using finite resources to achieve the goals of its owner and having clearly marked borders, which realize the privacy requirements. The user tasks that compose an activity are supported by an ad-hoc orchestration of ubiquitous computing services, which are manifested via an ecology of smart artefacts. The bubble adapts to different contexts by re-negotiating its borders, adopting suitable interaction modes and employing resource management models. In ATRACO, adaptation will be researched in terms of artefact operation, ecology composition, network election and man-machine interaction with respect to user context and behaviour.

The book edition consists of eight chapters each covering a detailed look on a specific scientific area within the field of Intelligent Environments. The first chapter describes a middleware architecture that has been developed for the ATRACO prototype. The second chapter deals with the networking aspects, which are crucial within the context of ambient intelligent systems. The third chapter provides a detailed insight into on the theoretical and the practical approaches to ontology-based knowledge management. Chapter 4 presents one of the most important adaptation mechanism used within ATRACO realized as advanced fuzzy mechanism. Chal-

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<sup>1</sup> <http://www.uni-ulm.de/in/atracoco>

lenges and novel approaches to adaptive user interaction between users and Intelligent Environments are discussed in Chapter 5. Planning and artificial intelligence is the main matter of the sixth chapter. Since privacy and trust issues are especially pertinent to ambient systems and computer-based systems that are used in our daily lives we have dedicated the Chapter 7 to this topic. The edition concludes with the evaluation methods and results of the social evaluation that has been conducted within the framework of the ATRACO project.

We are convinced that computer scientists, engineers, and others who work in the area of Ambient Environments, no matter if in academia or in industry, may find the edition interesting and useful to their own work. Graduate students and PhD students specialising in the area of Intelligent Environments more generally, or focusing on issues related to the specific chapters in particular, may also use this book to get a concrete idea of how far research is today in the area and of some of the major issues to consider when developing Intelligent Environments in practice. We would like to express our sincere gratitude to all those who helped us in preparing this book. Especially we would like to thank all reviewers who through their valuable comments and criticism helped improve the quality of the individual chapters as well as the entire book.

Ulm (Germany),  
June 2011

*Tobias Heinroth  
Wolfgang Minker*

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The research leading to these results has received funding from the European Community's 7th Framework Programme (FP7/2007-2013) under grant agreement n° 216837 and from the Transregional Collaborative Research Centre SFB/TRR 62 "Companion-Technology for Cognitive Technical Systems" funded by the German Research Foundation (DFG).



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# Acronyms

AA	Artefact Adaptation
AE	Ambient Ecology
AS	Activity Sphere
FTA	Fuzzy Task Agent
IA	Interaction Agent
IE	Intelligent Environment
LO	Local Ontology
NA	Network Adaptation
OM	Ontology Manager
PA	Planning Agent
PM	Privacy Manager
SA	Sphere Adaptation
SM	Sphere Manager
SO	Sphere Ontology
TM	Trust Manager
UBA	User Behaviour Adaptation
UIA	User Interaction Adaptation
UPnP	Universal Plug and Play
UX	User Experience

