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Agents and Ambient Intelligence
Achievements and Challenges in the Intersection of Agent Technology and Ambient Intelligence

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Throughout the history of mankind, human beings have always had a strong drive to develop tools that could support them in their daily activities. Examples of such artefacts are countless and vary from early hand-axes made out of stone to various types of 21st century computing devices.

There is little doubt that the development of human tools has been considerably accelerated by events like the industrial and the digital revolution. However, another perhaps less notable, but nevertheless important innovation during the history of human tool development is characterised by the introduction of increasingly autonomous artefacts, or agents.

Driven by the growing potential of digital computers in the mid-20th century, the idea that computational systems could be capable of performing certain tasks autonomously (‘on behalf of their human users’) gradually gained space in the decades that followed. Eventually, the concept of an intelligent agent became widely adopted in the early 1990s. Although many definitions were used, the term roughly referred to an autonomous entity that observes its environment via sensors and acts upon it via actuators, and is able to communicate with other agents. Depending on ones viewpoint, several additional properties were ascribed to agents, such as goal directedness and the ability to learn. At the time, the term was mostly applied to software agents (such as shopping bots), although the notion of hardware agents (robots) was used as well.

Partly in parallel with the intelligent agent paradigm, another concept emerged in the late 1990s, namely the perspective of Ambient Intelligence. As the readers of this book series probably know, Ambient Intelligence (AmI) was put forward as a vision on the near future of computing. As such, it referred to a world in which human beings are surrounded by intelligent electronic systems that are unobtrusively incorporated in their environment, monitor their behaviour using sensors, and support them in their daily activities.

Now that the concepts of intelligent agents and AmI have become more mature, it seems to be an appropriate moment to reflect on the research area that integrates the two. When comparing the definitions of both concepts, a number of overlapping elements can be identified (which in turn may be interpreted as arguments why it makes sense to combine both areas). First of all, the intelligent agent paradigm may serve as a useful conceptual framework to talk about AmI systems. Since AmI systems themselves are often (partly) autonomous systems, which observe (the humans in) their environment and act upon them, it takes a relatively small step to state that any AmI system is in fact an intelligent agent. Consequently, all the properties that were traditionally ascribed to (varying classes of) agents, such as goal directedness and adaptivity, could in principle be re-used for AmI systems as well.
A second reason why it may be relevant to study the intersection of intelligent agent technology and AmI is related to the notion of *multi-agent systems*. An interesting characteristic of intelligent agents, which I have not mentioned so far, is the fact that in practice there are often *multiple* of them. After all, an important asset of intelligent agents is that they are social entities with the ability to communicate amongst each other, enabling them to potentially solve complex problems in a distributed manner. Since AmI systems are typically active in complex and dynamic real world environments, and possibly have to interact with humans via different modalities and at different locations, the capacity to solve tasks in a distributed manner seems to be highly beneficial for such systems. Therefore, instead of treating an AmI system as one individual agent, the notion of a multi-agent system may sometimes be a suitable metaphor as well.

Inspired by these similarities between agent technology and Ambient Intelligence, the main purpose of the current book is to provide an overview about the state-of-the-art of the scientific area that integrates the two. And indeed, this entails that some chapters focus more on AmI systems that can be seen as one single intelligent agent, whereas others address AmI systems that are composed of multiple agents.

The chapters included in this book address a wide variety of topics related to agents and AmI, including theoretical as well as practical issues, design-related as well as implementation-related issues, ethical as well as philosophical issues, and so on. For obvious reasons, there is no straightforward order in which the different chapters should be presented. Nevertheless, in an attempt to create some structure, the 12 chapters have been clustered into four parts of three chapters, which can loosely be described as follows:

1) ethical and philosophical issues of agent-based AmI systems
2) methods for development of agent-based AmI systems
3) towards more intelligent and adaptive agent-based AmI systems
4) applications of agent-based AmI systems

In a way, the order in which these four parts are presented can be seen as going from general to specific, of from abstract to concrete.

More in particular, the first part contains three chapters that discuss ethical and philosophical issues behind the general principle of agent-based AmI systems, such as the ambitions behind the AmI vision (Heylen), the possibilities to define a conceptual framework to describe agent-based AmI systems, inspired by notions such as Mirror Worlds and stigmergy (Castelfranchi et al.), and the responsibilities for users and designers of these systems (Detweiler et al.).

The second part comprises three chapters that present and explore various approaches that can be used to develop agent-based AmI systems. These approaches include the use of verification tools to support the design of correct systems (Augusto et al.), an agent-based simulation approach to test the behaviour of AmI systems (specifically for the domain of location-based services) before their actual implementation (Martinez et al.), and a middleware-based approach used to embed agents within AmI systems (O’Hare et al.).

The third part consists of three chapters that share the goal to endow AmI systems with useful properties like intelligence and adaptivity. In particular, these chapters introduce (and evaluate) a novel approach to learn timing of prompts in agent-based smart homes (Das et al.), an approach to personalise the level of autonomy of agent-
based AmI systems (Ball et al.), and an overview of logic-based approaches for intention recognition in these systems (Sadri).

The fourth and last part of the book is composed of three chapters that present concrete applications of agent-based AmI systems. These applications include a system for user identity verification in the security domain (Dovgan et al.), a system for group emotion support (Duell et al.), and an approach to equip conversational systems with humour (Dybala et al.).

The combination of chapters included in this volume provides more insight in recent achievements as well as future challenges in the intersection of agent technology and Ambient Intelligence. It presents enlightening examples of how agent technology can be used to develop more intelligent, flexible, effective and user-friendly AmI systems, but also poses critical questions concerning the future of the AmI perspective, and the role of the agent paradigm therein.

To conclude, I wish to express my gratitude to all who contributed to the publication of this book, including all authors for sharing their interesting research with us, all reviewers for guarding the quality of the chapters, and last but not least, to the editor-in-chief and the publisher of the AISE book series for offering me the opportunity to publish this volume.

Amsterdam, March 15, 2012
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