Ambient Intelligence

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INTRODUCTION

In recent years much research and development effort has been directed towards the broad field of **ambient intelligence (AmI)**, and this trend is set to continue for the foreseeable future. AmI aims at seamlessly integrating services within smart infrastructures to be used at home, at work, in the car, on the move, and generally in most environments inhabited by people. It is a relatively new paradigm rooted in ubiquitous computing, which calls for the integration and convergence of multiple disciplines, such as sensor networks, portable devices, intelligent systems, human-computer and social interactions, as well as many techniques within artificial intelligence, such as planning, contextual reasoning, speech recognition, language translation, learning, adaptability, and temporal and hypothetical reasoning.

The term AmI was coined by the European Commission, when in 2001 one of its Programme Advisory Groups launched the AmI challenge (Ducatel et al., 2001), later updated in 2003 (Ducatel et al., 2003). But although the term AmI originated from Europe, the goals of the work have been adopted worldwide, see for example (The Aware Home, 2007), (The Oxygen Project, 2007), and (The Sony Interaction Lab, 2007).

The foundations of AmI infrastructures are based on the impressive progress we are witnessing in wireless technologies, sensor networks, display capabilities, processing speeds and mobile services. These developments help provide much useful (row) information for AmI applications. Further progress is needed in taking full advantage of such information in order to provide the degree of intelligence, flexibility and naturalness envisaged. This is where **artificial intelligence** and **multi-agent techniques** have important roles to play.

In this paper we will review the progress that has been made in intelligent systems, discuss the role of artificial intelligence and **agent technologies** and focus on the application of AmI for independent living.

BACKGROUND

Ambient intelligence is a vision of the information society where normal working and living environments are surrounded by **embedded intelligent devices** that can merge unobtrusively into the background and work through intuitive interfaces. Such devices, each specialised in one or more capabilities, are intended to work together within an infrastructure of **intelligent systems**, to provide a multitude of services aimed at generally improving safety and security and improving quality of life in ordinary living, travelling and working environments.

The European Commission identified four AmI scenarios (Ducatel et al. 2001, 2003) in order to stimulate imagination and initiate and structure research in this area. We summarise two of these to provide the flavour of AmI visions.

AmI Scenarios:

1. Dimitrios is taking a coffee break and prefers not to be disturbed. He is wearing on his clothes or body a voice activated digital avatar of himself, known as Digital Me (D-Me). D-Me is both a learning device, learning about Dimitrios and his environment, and an acting device offering communication, processing and decision-making functionalities. During the coffee break D-Me answers the incoming calls and emails of Dimitrios. It does so smoothly in the necessary languages, with a re-production of Dimitrios' voice and accent. Then D-Me receives a call from Dimitrios' wife, recognises its urgency and passes it on to Demetrios. At the same time it catches a message from an older person's D-Me,

located nearby. This person has left home without his medication and would like to find out where to access similar drugs. He has asked his D-Me, in natural language, to investigate this. Dimitrios happens to suffer from a similar health problem and uses the same drugs. His D-Me processes the incoming request for information, and decides neither to reveal Dimitrios' identity nor offer direct help, but to provide the elderly person's D-Me with a list of the closest medicine shops and potential contact with a self-help group.

2. Carmen plans her journey to work. It asks AmI, by voice command, to find her someone with whom she can share a lift to work in half an hour. She then plans the dinner party she is to give that evening. She wishes to bake a cake, and her e-fridge flashes a recipe on the e-fridge screen and highlights the ingredients that are missing. Carmen completes her shopping list on the screen and asks for it to be delivered to the nearest distribution point in her neighbourhood. All goods are smart tagged, so she can check the progress of her virtual shopping from any enabled device anywhere, and make alterations. Carmen makes her journey to work, in a car with dynamic traffic guidance facilities and traffic systems that dynamically adjust speed limits depending on congestion and pollution levels. When she returns home the AmI welcomes her and suggests that on the next day she should telework, as a big demonstration is planned in downtown.

The demands that drive AmI and provide opportunities are for improvement of safety and quality of life, enhancements of productivity and quality of products and services, including public services such as hospitals, schools, military and police, and industrial innovation. AmI is intended to facilitate human contact and community and cultural enhancement, and ultimately it should inspire trust and confidence.

Some of the technologies required for AmI are summarised in Figure 1.

AmI work builds on ubiquitous computing and sensor network and mobile technologies. To provide the intelligence and naturalness required, it is our view that significant contributions can come from advances in artificial intelligence and agent technologies. **Artificial intelligence** has a long history of research on planning, scheduling, temporal reasoning, fault diagnosis, hypothetical reasoning, and reasoning with incomplete and uncertain information. All of these are techniques that can contribute to AmI where actions and decisions have to be taken in real time, often with dynamic and uncertain knowledge about the environment and the user. Agent technology research has concentrated on agent architectures that combine several, often cognitive, capabilities, including reactivity and adaptability, as well as the formation of agent societies through communication, norms and protocols.

Recent work has attempted to exploit these techniques for AmI. In (Augusto and Nugent 2004) the use of temporal reasoning combined with active data-

Figure 1. Components of Ambient Intelligence