Intelligent Agile Agents: Active Enablers for Ambient Intelligence

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This paper advocates the use of mobile intentional agents as a key enabler in the delivery of ambient intelligence. Ambient computing as an ideal demands levels of functional attainment that have hithertofar not been realised. Ambient applications demand that the computing application be subsumed into the everyday *context* in an unobtrusive manner with interaction modalities such that they are natural, simple and appropriate to both the individual user and their associated context.

Ambient systems need to address some key issues:

1. Recognition and accommodation of the diversity of devices that contribute to the organic nature of the ambient and ubiquitous computing nervous system;
2. The need for personalisation and system adaptivity;
3. An understanding of the dynamics of context;
4. Provision of support for collaboration and cooperation between distributed ambient system components;
5. Delivery of systems that exhibit autonomic characteristics yielding self management and self healing capabilities;

In addressing these core issues we commission an intentional agent based approach. Specifically we adopt a Belief Desire Intention (BDI) agent model. In the delivery of such agents we utilise the Agent Factory system. The Agent Factory (AF) System is an environment developed in part by one of the authors, which supports the rapid fabrication of agent-based applications. Agent Factory provides an integrated environment for the development of agent based systems providing a methodological framework together with an accompanying software membrane which provides a cohesive and integrated tool set which supports the various stages in the design, specification, implementation, debugging and visualisation of agent behaviour. Detailed descriptions of Agent Factory are provided elsewhere in the literature [1, 2]. Agent Factory supports *Weak Migrat*ion where only the agent's object state and code is captured. Upon migration the system calls a known entry-point in the code to restart the agent on the new machine.

Within this paper we explore the delivery of ambient computing through the examination of three case studies, namely Gulliver's Genie, Easishop and Autonomic Wireless Sensor Networks (AWSN). We use these to illustrate how our agile intentional agents contribute to overcoming the key issues identified above. These applications are chosen as they represent three scenarios that necessitate scientific discovery. Gulliver's Genie necessitates the identification of individual tourist profiles. Easishop demands the examination and formulation of buyer and seller behaviour and ultimately the understanding of the particular m-commerce macro economy. The AWSN scenario is more far reaching in that the monitoring of the environmental nervous system presents limitless possibilities in terms of scientific discovery. This paper will consider each in turn.

At its simplest, Gulliver's Genie may be regarded as a mobile context-aware tourist guide. In many respects, it is a classic example of an mobile application or service that many people would anticipate being available in the coming years. In this it is not unique as the literature is sprinkled with prototypical systems for various application domains. Gulliver's Genie harvests concepts from a number of disciplines. It exhibits context-awareness, adaptivity and incorporates principles from user modelling. One of its distinguishing features is its proactive anticipation of user needs and the subsequent intelligent precaching of multimedia content on the tourist's host device thus achieving the distribution of content in a just-in-time basis [3].

Easishop [4,5] meanwhile is a pioneering m-commerce system that embraces a rich technological set. Easishop distinguishes itself in various important respects. Each shopper is provided with a shopping agent which is

entrusted to assist with their personal shopping requirements. This is achieved through the profiling of users and the dynamic maintenance of user profiles. Agents are mobile in nature and migrate to a market place and participate in an auction adopting a Contact Net Protocol. Shops are also ascribed agents entrusted with the sale of their products. The purchase process is negotiative in nature with sellers and purchasers alike active participants contributing to a true macro economy. Product acquisition is facilitated through the use of the UNSPSC product ontology together with product description via XML. Agent migration and communication is supported over Bluetooth and using SMS over GSM. Scalability and stress testing have been conducted and performance results are promising, while user evaluations are currently on-going.

Autonomic Wireless Sensor Networks (AWSN), constitute a new generation of ubiquitous sensing technology. Such systems are typified by their highly distributed, complex real-time nature together with responsiveness to a dynamic and ever changing environment. We discuss how the portfolio of autonomic characteristics may be achieved within wireless sensor networks, through the deployment of mobile and agile agent-based technologies. Autonomic computing has for many been thought of as synonymous with powerful software systems running on resource rich hardware platforms. In this paper we aim to show that autonomic properties can be incorporated into distributed, computationally challenged devices typified by processing, power and memory limitations. These hardware elements have varying degrees of memory, processing and energy capacity, as well as a variety of transmission ranges. Typical of the sensor hardware that we consider are the Berkley Motes (figure 1) which have extremely limited resources. While they can support simple agents, they are not capable of running fully deliberative autonomic agents.

Figure 1: Berkley Micra2 Wireless Sensor Mote

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