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Context-Aware Service Provisioning in Next-Generation Networks:
An Agent Approach

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ABSTRACT

This article presents an application of a multi-agent system in ubiquitous computing scenarios characteristic of next-generation networks. Next-generation networks will create environments populated with a vast number of consumers, which will possess diverse types of context-aware devices. In such environments, the consumer should be able to access all the available services anytime, from any place, and by using any of its communication-enabled devices. Consequently, next-generation networks will require efficient mechanisms which can match consumers' demands (requested services) to network-operators' supplies (available services). The authors propose an agent approach for enabling autonomous coordination between all the entities across the telecom value chain, thus enabling automated context-aware service provisioning for the consumers. Furthermore, the authors hope that the proposed service discovery model will not only be interesting from a scientific point of view, but also amenable to real-world applications.

Keywords: *agent technology; electronic markets; intelligent agents; knowledge discovery; ontologies semantic matching; value chain*

INTRODUCTION

We are entering a period when everything becomes digitized and when almost all software and devices are innately network-aware (Leuf, 2006). This induces an explosion of smart things, thus enabling the creation of pervasive smart spaces. When in the late 1980s Mark Weiser identified three main eras of computing (Weiser & Brown, 1997), he envisioned a transformation of

physical spaces into computationally active and intelligent environments (Weiser, 1991). The first era was the era of mainframe computing, when large and powerful computers were shared by many people. The second era was the era of personal computing, when there was one computer per person. In the upcoming third era, we as humans will interact no longer with one computer at a time, but rather with a dynamic set of small networked computers, often invisible and embodied in everyday objects in the environment (Weiser, 1994). The third era is the era of *ubiquitous computing* (now also called *pervasive computing*), or the age of *calm technology*, when technology recedes into the background of our lives. "The most profound technologies are those that disappear", Weiser wrote. "They weave themselves into the fabric of everyday life until they are indistinguishable from it" (Weiser, 1991). The goal of ubiquitous computing is to create ambient intelligence where network devices embedded in the environment provide seamless connectivity and services all the time, thus improving human experience and quality of life without explicit awareness of the underlying communications and computing technologies. In the multi-agent system presented in this article, the pervasive computing concept is applied while creating such an environment which aims to minimize distractions on a consumer's attention and that adapts to the consumer's context and needs (Garlan, Siewiorek, Smailagic, & Steenkiste, 2002). In such an environment, diverse types of ubiquitous communication-enabled devices are used as a consumer's quiet and invisible servants, the enablers of calm technology.

Almost 20 years ago, at the time when Weiser tried to make his vision a reality, there were too many technological restraints for creating the real-world environment grounded on the ubiquitous computing concept. Meanwhile, tremendous developments in wireless technologies and mobile telecommunication systems, as well as rapid proliferation of various types of portable devices, have significantly amended computing lifestyles, thus advancing Weiser's vision toward technical and economic viability (Saha & Mukherjee, 2003). Weiser's ideas are becoming reality as the new generation of communication systems. The upcoming next-generation network (NGN) is characterized with evolution towards an all-IP (*Internet Protocol*) network, as well as with convergence of mobile and wireline networks into a single unified infrastructure. Figure 1 presents the key processes and the main actors which can be identified during the service provisioning in the NGN environment. Processes characteristic for the service provisioning life cycle are *discovery*, *fulfillment*, and *charging*. The main actors are *consumers* with their mobile/wireless terminals, *network operators*, and *content providers*. Usually, the network operator will offer services to the consumers, establishing a B2C (*Business-to-Consumer*) relationship with them. On the other hand, since the network operator very often does not possess the content needed for provisioning the service, it also has to establish B2B (*Business-to-Business*) relationships with the content providers. The essential step for the success of the NGN concept is creating a business model that produces added value for all the involved parties (consumers, network operators, content providers). Added value is created for the consumers if their level of satisfaction with the consumed service is more valuable than the money they have paid for the service provisioning. On the other hand, network operators and content