Chapter 8
From SOA to Pervasive Service Ecosystems: An Approach Based on Semantic Web Technologies

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ABSTRACT
Emerging pervasive computing scenarios require open service frameworks promoting situated adaptive behaviors and supporting diversity in services and long-term ability to evolve. The authors argue that this calls for a nature-inspired approach in which pervasive services are modeled and deployed as autonomous individuals in an ecosystem of other services, data sources, and pervasive devices. They discuss how standard service-oriented architectures have to evolve to tackle the above issues, present a general architecture based on a shared spatial substrate mediating interactions of all the individual services of the pervasive computing system, and finally show that this architecture can be implemented relying primarily on standard W3C Semantic Web technologies, like RDF and SPARQL. A use case of adaptive pervasive displays for crowd steering applications is exploited as reference example.

INTRODUCTION
The ICT landscape, notably changed by the advent of ubiquitous wireless connectivity, is further reshaping due to the increasing deployment of pervasive computing technologies. Via RFID tags and similar technologies, objects will carry a wide range of digital, self-describing information. Wireless sensor networks and camera networks will spread across our cities and buildings to monitor physical phenomena. Smartphones and other personal devices will increasingly sense and store
notable amounts of data related to our personal, social and professional activities, beyond feeding (and being fed by) the Web with spatial and social real-time information (Campbell et al., 2008).

This evolution is contributing to building integrated and dense infrastructures for the pervasive provisioning of general-purpose digital services. If all their components are able to opportunistically connect with each other, such infrastructures can be used to enrich existing services with the capability of autonomously adapting their behavior to the physical and social context in which they are invoked, and will also support innovative services for enhanced interactions with the surrounding physical and social worlds (Coleman, 2009).

Users will play an active role by contributing data and services and by making available their own sensing and actuating devices. This will make pervasive computing infrastructures as participatory and as capable of value co-creation as the Web (Spohrer et al., 2007), eventually acting as globally shared substrates to externalize, enhance, and make more valuable our physical and social intelligence.

We already face the commercial release of a variety of early pervasive services trying to exploit the possibilities opened by these new scenarios: GPS navigation systems providing real-time traffic information and updating routes accordingly, cooperative smartphones that inform us about the current positions of our friends, and augmented reality services that enrich what we see around with dynamically retrieved digital information (Ferscha and Vogl, 2010). However, the road towards the effective and systematic exploitation of these emerging scenarios calls for a radical rethinking of current service models and frameworks.

Elaborating on this problem, this chapter is organized as follows:

- In Section 2 we provide a background: starting from a case study of adaptive pervasive displays, we discuss the basic requirements of emergent pervasive computing applications, namely situatedness, adaptation, and support for diversity and long-term evolution.
- In Sections 3-5 we present the main focus of the chapter: we propose how current SOA solutions are to be evolved to tackle those requirements, namely, by a deep rethinking inspired by nature and its mechanisms, promoting the idea of a “pervasive and shared spatial continuum” over which local individual interactions occur; and we present an innovative architecture for pervasive service ecosystems rooted in the concepts of “Live Semantic Annotations” (LSAs, representing interfaces of environment services) and “eco-laws” (global coordination rules enabling and regulating interactions). In Section 4 an implementation of the framework based on standard W3C technologies for the Semantic Web is discussed, namely, relying on RDF for supporting LSAs, and SPARQL for eco-laws; Section 5 presents a concrete example in the form of a crowd steering example.
- In Section 6 we discuss related works.
- Finally, in Section 7, we conclude by describing the future directions of the presented research.

BACKGROUND

As background for this chapter, we present the pervasive computing scenarios we intend to target, so as to emphasize the requirements they pose. We do this by means of a simple case study – representative of a larger class of emerging pervasive scenarios – which will be used to ground our arguments, sketch the requirements of future pervasive services, and ultimately discuss the proposed service framework.

It is a matter of fact that we are increasingly surrounded by digital displays: from those of wearable devices to wide wall-mounted displays.