# Chapter 2.22
# Semantic Web Services for Smart Devices Based on Mobile Agents

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## ABSTRACT

Among traditional users of Web resources, industry has a growing set of smart industrial devices with embedded intelligence. Just like humans, they need online services (i.e., for condition monitoring, remote diagnostics, maintenance, etc.). In this paper, we present one possible implementation framework for such Web services. Such services should be Semantic Web enabled and form a Service Network based on internal and external agents' platforms, which can host heterogeneous mobile agents and coordinate them to perform needed tasks. The concept of a "mobile service component" assumes not only exchanging queries and service responses, but also delivering and composition of a service provider. Mobile service component carrier (agent) can move to a field device's local environment (embedded agent platform) and perform its activities locally. Service components improve their performance through online learning and communication with other components. Heterogeneous service components' discovery is based on semantic P2P search.

## INTRODUCTION

The intersection of Web Service, Semantic Web, and Enterprise Integration Technologies is recently drawing enormous attention throughout academia and industry (Bussler et al., 2003), and the expectation is that Web Service technology in conjunction with Semantic Web Services will make Enterprise Integration dynamically possible for various enterprises compared to the traditional technologies (Electronic Data Interchange or Value Added Networks).

The Semantic Web is an initiative of the World Wide Web Consortium with the goal of extending the current Web to facilitate Web automation, universally accessible content, and the Web of Trust. Tim Berners-Lee (Berners-Lee et al., 2001) has a vision of a Semantic Web, which has ma-

chine-understandable semantics of information, and trillions of specialized reasoning services that provide support in automated task achievement based on the accessible information. Management of resources in Semantic Web is impossible without use of ontologies, which can be considered as high-level metadata about semantics of Web data and knowledge (Chandrasekaran et al., 1999). DAML-S or DAML for Services (Ankolekar et al., 2002; Paolucci et al., 2002) provides an upper ontology for describing properties and capabilities of Web services in an unambiguous, computer-interpretable markup language, which enables automation of service use by agents and reasoning about service properties and capabilities. There also is a growing interest in the use of ontologies in agent systems as a means to facilitate interoperability among diverse software components (Ontologies, 2003). The problems related to that are being highlighted by a number of recent large-scale initiatives (e.g., Agentcities, Grid computing, the Semantic Web and Web Services). A common trend across these initiatives is the growing need to support the synergy between ontology and agent technology.

The key to Web Services is on-the-fly software composition through the use of loosely coupled, reusable software components (Fensel et al., 2002). Still, more work needs to be done before the Web service infrastructure can make this vision come true. Among the most important European efforts in this area is the SWWS (Semantic Web and Web Services, swws.semanticweb.org) project, which is intended to provide a comprehensive Web Service description, discovery, and mediation framework.

Usually a Web service is accessed by human users or by applications on behalf of human users. However, there already exists a growing new group of Web service users, which are smart industrial devices, robots, or any other objects equipped by embedded intelligence. There is a need to launch special Web services for such smart industrial devices. Such services will provide necessary online information provisioning for the devices, allow the heterogeneous devices to communicate and exchange data and knowledge with each other, and even support cooperation between different devices. There are many open questions to be answered within this research area.

In this paper, we discuss an approach for implementing emerging Semantic Web and Web services technologies to a real industrial domain, which is field device management. The goal of this paper is to discuss possible implementation framework to Web services that automatically follow up and predict the performance and maintenance needs of field devices.

The rest of the paper is organized as follows: Section 2 briefly introduces our concepts of an intelligent agent and mobility; Section 3 presents two alternative architectures for distributed problem solving based on mobile agents; Section 4 describes the domain of field device maintenance and ways of implementing agents in it; Section 5 discusses implementation issues related to the Web service network (OntoServ.Net) of smart devices based on integration of Semantic Web services and multiagent technologies; Section 6 concludes.

## AGENTS, SEMANTIC BALANCE, AND MOBILITY

In spite of the existence of many definitions for the concept of an intelligent agent, we will use our own. The definition is based on the concept of Semantic Balance (Terziyan & Puuronen, 1999). In Figure 1, the concept of internal and external environments is illustrated.

We consider Intelligent Agent as an entity that is able to keep a continuous balance between its internal and external environments in such a way that in the case of unbalance, the agent can choose a behavioral option from the following list: