Chapter III
Global Understanding Environment: Applying Semantic and Agent Technologies to Industrial Automation

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ABSTRACT

Industry pushes a new type of Internet characterized as the Internet of Things, which represents a fusion of the physical and digital worlds. The technology of the Internet of Things opens new horizons for industrial automation, that is, automated monitoring, control, maintenance planning, and so forth, of industrial resources and processes. Internet of Things definitely needs explicit semantics, even more than the traditional Web—for automatic discovery and interoperability among heterogeneous devices and also to facilitate the behavioral coordination of the components of complex physical-digital systems. In this chapter, the authors describe their work towards the Global Understanding Environment (GUN), a general middleware framework aimed at providing means for building complex industrial systems consisting of components of different nature, based on the semantic and the agent technologies. The authors present the general idea and some emergent issues of GUN and describe the current state of the GUN realization in the UBIWARE platform. As a specific concrete case, they use the domain of distributed power network maintenance. In collaboration with the ABB Company, we have developed a simple prototype and vision of potential add-value this domain could receive from introducing semantic and agent technologies, and GUN framework in particular.

INTRODUCTION

Recent advances in networking, sensor and RFID technologies allow connecting various physical world objects to the IT infrastructure, which could, ultimately, enable realization of the Internet of Things and the ubiquitous computing visions. This also opens new horizons for industrial automation, i.e. automated monitoring, control, maintenance planning, etc., of industrial resources and processes. A much larger, than in present, number of resources (machines, infrastructure elements, materials, products) can get connected to the IT systems, thus be automatically monitored and potentially controlled. Such development will also necessarily create demand for a much wider integration with various external resources, such as data storages, information services, and algorithms, which can be found in other units of the same organization, in other organizations, or on the Internet.

Such interconnectivity of computing and physical systems could, however, become the "nightmare of ubiquitous computing" (Kephart and Chess, 2003) in which human operators will be unable to *manage* the complexity of interactions, neither even architects will be able to *anticipate* this complexity and thus *design* the systems effectively. It is widely acknowledged that as the networks, systems and services of modern IT and communication infrastructures become increasingly complex, traditional solutions to manage and control them seem to have reached their limits. The IBM vision of autonomic computing (e.g. Kephart and Chess, 2003) proclaims the need for computing systems capable of running themselves with minimal human management which would be mainly limited to definition of some higher-level policies rather than direct administration. The computing systems will therefore be *self-managed*, which, according to the IBM vision, includes self-configuration, self-optimization, self-protection, and self-healing. According to this vision, the self-manageability of a complex system requires its components to be to a certain degree autonomous themselves. Therefore, we envision that agent technologies will play an important part in building such complex systems. Agent-based approach to software engineering is also considered to be facilitating the *design* of complex systems (see Section 2).

Another problem is inherent *heterogeneity* in ubiquitous computing systems, with respect to the nature of components, standards, data formats, protocols, etc, which creates significant obstacles for interoperability among the components of such systems. The semantic technologies are viewed today as a key technology to resolve the problems of interoperability and integration within heterogeneous world of ubiquitously interconnected objects and systems. The Internet of Things should become in fact the *Semantic Web of Things* (Brock and Schuster, 2006). Our work subscribes to this view. Moreover, we believe that the semantic technologies can facilitate not only the discovery of heterogeneous components and data integration, but also the behavioral coordination of those components (see Section 2).

In this paper, we describe our work on the *Global Understanding Environment (GUN)* (the concept introduced in Terziyan, 2003, 2005). This work is conducted in the line of projects of the Industrial Ontologies Group at the University of Jyväskylä including SmartResource (2004-2007, see http://www.cs.jyu.fi/ai/OntoGroup/SmartResource_details.htm) and ongoing UBIWARE (Smart Semantic Middleware for Ubiquitous Computing, 2007-2010, see http://www.cs.jyu.fi/ai/OntoGroup/UBIWARE_details.htm). GUN is a general middleware framework aiming at providing means for building complex industrial systems consisting of components of *different* nature, based on the semantic and agent technologies. A very general view on GUN is presented in Figure 1; a description of GUN will be given in Section 3.

When applying the semantic approach in the domain of industrial automation, it should be obvi-