Chapter 75

On the Updating of Domain OWL Models at Runtime in Factory Automation Systems

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ABSTRACT

Software agents controlling production devices must maintain an up-to-date view of the physical world state in order to efficiently reason and plan their actions. Especially in a factory automation system, the world state undergoes rapid evolution. To enable accurate decision-making, the world view must constantly be synchronized with the changes. This paper discusses two approaches to updating the world view based on event notifications sent by web services representing production devices in a manufacturing system. One approach requires that a set of update rules is separately specified, whereas the other involves automatically deriving the update rules from the semantic web service descriptions. While this paper specifically focuses on the factory automation domain, both of the approaches presented are applicable to other domains as well. The main assumptions are that the domain is composed of world-altering web services, which provide adequate service interfaces to detect changes in their state, and that all relevant changes in the overall domain state can be directly derived from the service state changes.

INTRODUCTION

Controlling a manufacturing system requires developing a comprehensive knowledge representation of the system. An ontology-based knowledge representation of a factory automation system allows reusing the domain model in several autonomous software agents (Martinez Lastra & Delamer, 2009). The

domain model must describe the different processes performed in the production system and the services that offer the processes (Martinez Lastra & Delamer, 2009). OWL (The Web Ontology Language) (McGuinness & van Harmelen, 2004) is currently the de facto standard for representing ontologies in a machine-interpretable format. For example, the OWL-S (Martin et al., 2007) ontology for web services is based on OWL.

In a flexible manufacturing system whose devices expose web service interfaces, the domain model must be initialized at system start-up and continuously updated at run-time. For this purpose, a client application may poll the state of the web services by using the request-response type operations in the service interfaces (Uddin, Dvoryanchikova, Lobov, & Lastra, 2011). However, the periodic polling introduces a steady overhead even during periods when no changes occur in the system. Moreover, the polling period must be set sufficiently short to reduce the risk of using outdated information.

This paper investigates the approach of updating the domain model based on event notifications received from the domain web services, which in the factory automation domain are production devices, such as robots and conveyors. The approach eliminates the need of periodic polling of service statuses, but introduces some additional challenges, such as the requirement of notification operations in the domain service interfaces.

This paper is organized as follows. First, the related work section surveys some of the recent contributions in the field of managing domain knowledge in factory automation systems. Then, another section presents two approaches to maintaining an up-to-date domain model. Then, the Application Examples section demonstrates the application of the two approaches in a specific production system scenario. Finally, the last section draws conclusions and describes potential points for further work.

RELATED WORK

Moser and Biffl (2012) investigate semantic integration between different ontologies and present an approach for maintaining a common ontology model to which tool-specific ontologies are mapped. The approach makes it possible for different stakeholders to use their own local data models while still allowing the validation of the entire combined runtime model (Moser & Biffl, 2012).

Another approach to integrate different domain ontologies is to use a common adaptable base ontology, which the domain specific ontologies extend (Uddin, Puttonen, Scholze, Dvoryanchikova, & Lastra, 2012). Such a hierarchical domain ontology can be constructed using a top-down or a bottom-up approach or a combination of the two (Sheng-tao Sun, Ding-sheng Liu, Guo-Qing Li, Wen-yang Yu, & Lv Pang, 2010). While using a common base ontology does facilitate the integration between different knowledge models (Sheng-tao Sun et al., 2010), it considerably restricts the development of domain-specific ontology models. Loskyll, Schlick et al. (2011) point out that when web services are mapped to concrete devices in the plant model, the service preconditions and effects make it possible to automatically update the plant model. Similarly, one of the domain model approaches presented in this paper is based on the semantic web service preconditions and effects.

The use of domain ontologies extends to several other application domains besides factory automation. For example, Evchina, Dvoryanchikova et al. (2012) apply domain ontologies in the control of automated systems installed into modern apartments. Tan et al. (2010) propose a general context model for businesses that appears independent of any particular domain. Similarly to Uddin et al. (2012), Tan et al. (2010) apply a hierarchical model, in which different domain-specific models share a set of core

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