Chapter 9

Integrating Production Automation Expert Knowledge Across Engineering Domains

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ABSTRACT

The engineering of a complex production automation system involves experts from several backgrounds, such as mechanical, electrical, and software engineering. The production automation expert knowledge is embedded in their tools and data models, which are, unfortunately, insufficiently integrated across the expert disciplines, due to semantically heterogeneous data structures and terminologies. Traditional integration approaches to data integration using a common repository are limited as they require an agreement on a common data schema by all project stakeholders. This paper introduces the Engineering Knowledge Base (EKB), a semantic-web-based framework, which supports the efficient integration of information originating from different expert domains without a complete common data schema. The authors evaluate the proposed approach with data from real-world use cases from the production automation domain on data exchange between tools and model checking across tools. Major results are that the EKB framework supports stronger semantic mapping mechanisms than a common repository and is more efficient if data definitions evolve frequently.

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INTRODUCTION

Industrial production automation systems depend on distributed software to control the system behavior. The behavior of automation systems must be testable and predictable to meet safety and quality standards. Modern automation systems have to be designed for better interoperability and flexibility to satisfy increasing customer needs for product variety, manufacturing agility, and low cost. In automation systems engineering (ASE) software engineering tasks depend on specification data and plans from a wide range of engineering expert domains in the overall engineering process, e.g., physical plant design, mechanical, and electrical engineering, and production process planning. This expert knowledge is embodied in domain-specific standards, terminologies, people, processes, methods, models, and software (Arndt Lüder, 2000).

However, a major challenge in current industrial development and research approaches is insufficient semantic model integration between the expert disciplines (Biffl, Moser, & Sunindyo, 2009; Schäfer & Wehrheim, 2007). Different and partly overlapping terminologies are used in these expert disciplines, which hampers understanding. Consequently, the weak tool support for semantic integration of the expert knowledge across domain boundaries hinders flexible engineering process automation and quality management, leading to development delays and risks for system operation.

The strategic goal of making the ASE process more flexible without delivering significantly more risky end products translates into the capability to efficiently re-configure the engineering process and tool instances of a project environment. While there are approaches based on a common repository that holds all relevant project data (Schäfer & Wehrheim, 2007), experience has shown that such a repository tends to get large, inflexible, and hard to maintain surprisingly fast, which makes the knowledge in the repository hard to reuse in new projects. Further, if several organizational units are involved in a project, even agreeing on a common data model is difficult. Thus a key goal is to allow all participants to continue using their own data models and provide a mechanism for translation between these data models. In the past several approaches for providing engineering knowledge in machine-understandable syntax have been investigated (Liao, 2005; Lovett, Ingram, & Bancroft, 2000; McGuire et al., 1993). However, these approaches focus primarily on storing existing homogeneous knowledge rather than providing support for managing and accessing heterogeneous knowledge, which is the focus of this work.

In this paper, we introduce an approach for semantic mapping in ASE with a focus on providing links between data structures of engineering tools and systems to support the exchange of information between these engineering tools and thus making ASE more efficient and flexible. The novel Engineering Knowledge Base (EKB) framework stores the engineering knowledge in ontologies and provides semantic mapping services to access design-time and run-time concepts and data. The EKB framework aims at making tasks, which depend on linking information across expert domain boundaries, more efficient. A fundamental example for such engineering tasks is checking the consistency and integrity of design-time and run-time models across tool boundaries (Wahyudin, Schatten, Winkler, Tjoa, & Biffl, 2008).

We evaluate the proposed approach with data from real-world use cases on assembly workshop engineering in the production automation domain. We compare the proposed EKB framework with the traditional approach using a repository with a common data schema for all involved tools. For the evaluation we compare the processes: a) setting up a translation mechanism using either the EKB framework or the common repository and b) using both evaluated approaches for the mentioned engineering task data model checking and analyses across tools for two use case scenarios.
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