The Unified Problem-Solving Method
Development Language UPML

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Abstract. Problem-solving methods provide reusable architectures and components for implementing the reasoning part of knowledge-based systems. The Unified Problem-Solving Method Description Language (UPML) has been developed to describe and implement such architectures and components to facilitate their semi-automatic reuse and adaptation. In a nutshell, UPML is a framework for developing knowledge-intensive reasoning systems based on libraries of generic problem-solving components. The paper describes the components and adapters, architectural constraints, development guidelines, and tools provided by UPML. UPML is developed as part of the IBROW project, which provides an Internet-based brokering service for reusing problem-solving methods.

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1. Introduction

Knowledge-based systems (KBSs) are computer systems that deal with complex problems by making use of knowledge. This knowledge may be acquired from

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humans or automatically derived using abductive, deductive, and inductive techniques. This knowledge is mainly represented declaratively rather than encoded using complex algorithms. This declarative representation of knowledge economizes the process of developing and maintaining these systems and improves their understandability. Therefore, knowledge-based systems originally used simple and generic inference mechanisms to infer outputs for cases provided. Inference engines, like unification, forward or backward resolution, and inheritance, dealt with the dynamic part of deriving new information. However, human experts can exploit knowledge about the dynamics of the problem-solving process and such knowledge is required to enable problem solving in practice and not only in principle. Clancey (1983) provided several examples where knowledge engineers implicitly encoded control knowledge by ordering production rules and premises of these rules which, together with the generic inference engine, delivered the desired dynamic behavior. Making this knowledge explicit and regarding it as an important part of the entire knowledge contained in a knowledge-based system is the rationale that underlies problem-solving methods (PSMs) (see Stefik, 1995; Benjamins and Fensel, 1998; Benjamins and Shadbolt, 1998; Fensel, 2000). Problem-solving methods refine the generic inference engines mentioned above to allow a more direct control of the reasoning process. Problem-solving methods describe this control knowledge independent of the application domain and thus enable the reuse of this strategic knowledge for different domains and applications. Finally, problem-solving methods abstract from a specific representation formalism, in contrast to the general inference engines that rely on a specific representation of the knowledge. PSMs decompose the reasoning tasks of a KBS in a number of subtasks and inference actions that are connected by knowledge roles. Therefore PSMs are a special type of software architecture (Shaw and Garlan, 1996) for describing the reasoning part of KBSs.

Several libraries of problem-solving methods are now available (see Marcus, 1988; Chandrasekaran et al., 1992; Puppe, 1993; Breuker and Van de Velde, 1994; Benjamins, 1995; Musen, 1998; Motta, 1999) and a number of problem-solving method specification languages have been proposed, ranging from informal notations (e.g., CML; Schreiber et al., 1994) to formal modeling languages (see Fensel and van Harmelen, 1994; Fensel, 1995; for summaries).

The 1BROW project1 (Benjamins et al., 1998; Fensel and Benjamins, 1998a) was established with the aim of enabling semi-automatic reuse of PSMs. This reuse is provided by integrating libraries in an Internet-based environment. A broker is provided that selects and combines PSMs of different libraries. A software engineer interacts with a broker that supports him in this configuration process. As a consequence, a description language for these reasoning components (i.e., PSMs) must provide comprehensible high-level descriptions with substantiated formal means to allow automated support by the broker. Therefore, we developed

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1 1BROW started with a preliminary phase under the 4th European Framework and has become a full-fledged Information Society Technologies (IST) project under the 5th European Framework Program since January 2000. Results of its initial phase are described in Benjamins et al. (1999), Benjamins and Fensel (1998), and Fensel et al. (1999b). Project partners are the University of Amsterdam; the Open University, Milton Keynes, UK; the Spanish Council of Scientific Research (IIIA) in Barcelona, Spain; the Institute AIFB, University of Karlsruhe, Germany; Stanford University, CA, USA; Intelligent Software Components SA, Spain; and the Vrije Universiteit Amsterdam.

http://www.swi.psy.uva.nl/projects/1BROW3/home.html