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Perspective on the design of a knowledge-based system embedding Linked Data for process planning

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Abstract

In simple terms, the Web of (Linked) Data is a distributed database with semantic facts about the world or any specific domain. The integration of Linked Data in knowledge-based systems (KBS) has the potential to reduce the maintenance effort for the underlying knowledge base. Using Linked Data in KBS leads to some new challenges that will be outlined in the paper. An important step during the design phase of the KBS is the comparison of the required knowledge and knowledge that is available as Linked Data. The required facts emerge from the problem-solving method and cover all facts that are necessary to conduct the intended decision. Whereas the available knowledge represent all relevant facts in internal and public Linked Data sets. Any remaining knowledge gap between required and available facts has to be closed primarily by rules and mash-ups to generate or transform the required facts automatically and keep everything up-to-date. This is one major step of the presented procedure and architecture to design a KBS based on Linked Data.

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Keywords: Linked Data; Ontology; Knowledge-based systems; Process planning

1. Introduction

The distribution of knowledge-based systems is associated with the emergence of the computer integrated manufacturing (CIM). It is assumed that expert systems and decision support systems provide high gains for the production management. However, knowledge-based systems like expert and decision support systems still lack of

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quick and simple possibilities to adapt the underlying knowledge base to changes in the real world. Even more so than in the past, the environment of a high flexible production system and individualized products changes continuously. As a consequence of this, the results provided by a knowledge-based systems is outdated very soon – except for making high efforts in maintaining the system.

1.1. Solution approach

The tasks of process planning follow a similar procedure in all shop floors. One step in this process is to find a capable and profitable machine for the manufacturing of a work piece. Knowledge-based systems include a knowledge base with all facts about the considered domain and a problem solving method that describes a standard reasoning procedure to solve generic or specific tasks that should be performed by the KBS.

The problem solving method for the selection of appropriate resources can be reused in different KBS in this field, because the logic to find a capable and profitable machine is always the same in different shop floors. The manufacturing equipment of contract manufactures is more or less standardized, especially when considering standard CNC machine tools. A KBS for process planning requires a description of available machines in the regarded shop floor. If machines are standardized this information could be provided by a shared knowledge base.

Sharing of knowledge by publishing in some way is not sufficient. The knowledge has to be described in a formal way to make it process able by machines and humans. Semantic technologies are considered to make this possible, more precisely the use of formal ontologies to describe facts and the Linked Data principles for the publishing of these facts [1]. In simple terms, the Web of Linked Data is a distributed database with semantic facts about the world or any specific domain. The major search engines are already using semantic technology to generate “rich answers” to specific user questions instead of providing only links to websites containing the keywords of the question [2]. This situation leads to the discussed topic: The design of a knowledge-based system embedding Linked Data for process planning. This means, integrating Linked Data in the underlying knowledge base. This will reduce the maintenance cost and keep the knowledge base of such systems up-to-date. The prerequisites for publishing the semantic descriptions of manufacturing equipment like machines are developed [15, 16]. However, what is lacking is the practical utilization in KBS and therefore the demand for manufacturing descriptions as Linked Data. Today, the idea of Linked Data is not well-known in the manufacturing, neither at the vendors of manufacturing equipment nor at the operating companies. To change this and to promote the development of Linked Data in the manufacturing domain, the presented design approach shows what becomes reality if descriptions of manufacturing equipment are published as Linked Data. Following scenario could become reality if facts describing new manufacturing equipment are available as Linked Data: The companies purchasing department orders new manufacturing equipment and the facts describing this new equipment are obtained from public Linked Data sets and integrated automatically in the knowledge base of the affecting KBS in the shop floor.

2. Beyond the web of documents

For same years now, the World Wide Web is subject to a continuous structural transformation that is not noticed by the majority: Initially, the Web of Documents was indented to be easily understandable for humans. In the last years the World Wide Web is being enhanced to a Web of Data, also known as Web 3.0. The Web of Data is not only composed of linked documents, but of semantic structured data, linked statements and references between this information. They can be processed by machines and - if visually prepared - also by humans [1,3]. Machines mean software with a particular intelligence. A bundle of different technologies subsumed under the label Semantic Technologies build the basis of the Web 3.0; therefore it got the byname Semantic Web. The Semantic Web describes what is the goal and Semantic Technologies describes how to realize that goal. A popular semantic technology is ontologies; they are recognized as a formal representation model for terms and definitions [17]. Ontologies provide a well-defined vocabulary to specify the meaning of elements in a knowledge area. They provide a foundation for a common understanding, for reasoning and knowledge reuse [18]. The components of ontologies are concepts, properties, axioms and individuals. Today, there exists different rich languages and subversions to