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Communication architecture for automatic plant documentation updates

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Abstract

Today's flexible demands and short product life cycles have lead to a modular thinking for machinery and plant engineering. A hidden challenge for this sector is the maintenance of plant documentation throughout the entire operating time of the machine components. This paper introduces an architecture for updating plant documentation. The concept is based on a flexible master-slave hierarchy for IT-integrated machine components and aims at detecting physical changes in them. The standard data exchange format AutomationML functions as a decentralized and up-to-date virtual representation of each component carrying all types and contents of both construction and documentation disciplines.

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Keywords: event-driven architecture; assembly and commissioning; cyber physical systems; mechanical and plant engineering

1. Introduction

After the initial operation of a machine, the technical documentation is, due to the long operating time, at a certain point within the life cycle no longer topical. Therefore, it is compulsory to add technical documentation updates to delivered machines. This paper introduces a hierarchy concept to update a virtual machine or plant representation so that components can be added and removed in the Cyber Physical System (CPS) without any loss of topicality for the machine documentation. For this reason, this article introduces an application scenario for changing welding torches to explain the general architecture.

1.1. Technical documentation

An up-to-date technical documentation is essential to conform to the machine guidelines of 2006/42/EG[1]. Technical documentation includes the technical documents of the machine and plant producer in addition to the declaration of conformity. These documents are the basis to place a machine or plant in the market and into operation. Important details for the documentation are information about the construction, design and functions. These documentation parts will be divided into an internal and external technical documentation[2].

1.2. Application scenario

Carl Cloos Schweisstechnik GmbH (Cloos) develops, manufactures and delivers innovative welding machines for manual and automated applications. After delivery, it is a normal process to change components in a machine life cycle. The life cycle process can be divided into three phases: the beginning of life, middle of life and end of life. A common and recommended way in the end-of-life phase is to reuse components, complete machines or entire plants and integrate such components in a new way. Within a production plant (middle of life) this is a usual change process, too[3]. Therefore, Cloos conducts, for the application scenario, a retooling of different welding torches (i. e. metal active gas (MAG) and tungsten inert gas (TIG) welding): the TIG welding torch (figure 1 on the right) and a robot with the MAG welding torch (presented on the left). In addition, they apply different welding torches using different power supply modules and cable assemblies. However, a more important aspect is that the torch exchange leads to an obsolete technical documentation for the entire machine because the new welding technology documentation is frequently not delivered afterwards. In the case of Cloos, documentation is created as a closed unit. It would be very helpful if the up-to-dateness of the technical documentation and of the process was supported by a software program.

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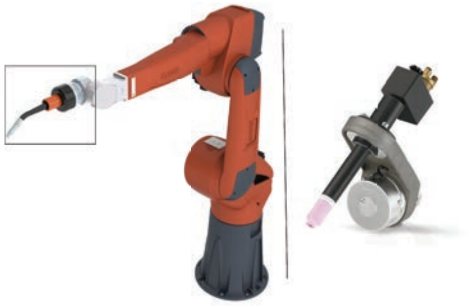

Figure 1. robot-based welding power source: welding robot (left) with a MAG welding torch (in the left box), TIG welding torch (right), source: Carl Cloos Schweisstechnik GmbH

2. Requirements

An upcoming change of perception in the manufacturing industry is triggered by technologies like the Internet. Due to the continuous generation of data (like sensors, computer networks, data acquisition systems, and so on), the consumption of new platforms has risen dramatically. New Cyber Physical Systems (CPS) are now at the center of attention in order to combine physical systems and virtual representations[4]. In an industrial context, more and more information about the machine state, different sensors or products are needed, following i. e. [4,5]. This supposes that a machine is fully described in the cyber physical context. This implies different requirements for technical documentation within a Cyber Physical System, respectively a Cyber Physical Production System (CPPS) concerning the entire plant or machine. The demand to record technical documentation and the derived technological requirements are described below.

2.1. Provision of technical documentation

The relevance to create documentation for machines has risen significantly in the last years. The term technical documentation is defined here as internal documentation (i. e. stock-lists), proof of product features (i. e. risk assessment) and external documentation (i. e. spare parts catalogue)[6]. In an industrial context, technical documentation is an important topic. Three major requirements can be derived for the provision of technical documentation:

- entire documentation and process transparency
- currentness of the entire machine documentation
- context-based provision of technical documentation

The first aspect is concerned with the demand of an entire machine documentation along with transparency for the process. A full description contains i. e. instructions (reasonably foreseeable misuse included), notes on the functional principle, maintenance procedures, engineering drawings, circuit diagrams, etc. This is a legal obligation and necessity to take a machine into operation in Europe[1]. In the virtual context this implies that every machine component has to be fully described, too. Another necessary requirement, also derived from the machine guidelines, is the need for continuous updates. The current configuration has to be described for the machine so that the documentation is up to date, i. e. after a component change. A relatively new requirement in the industrial context without any legal reasons is the demand-actuated access to technical documentation. This approach uses technical documentation, needed in the legal context, to increase the availability of information. This attempt has a more practical influence and tries to use technical documentation as a direct support in the production process. A tool change like switching the welding torches (MAG to TIG) on a welding robot is a possible example. The information must be context-based if a constructor uses technical documentation for a machine as assistant support to construct a new component, since the mechanic is only interested in the tool change procedure and not in the circuit diagrams of the control unit. The up-to-date record for an entire machine is done manually by the manufacturing company and will not be updated after distribution because tool replacement or other changes cannot and will not be detected. Because of this missed update, the currentness of a machine is not given and, therefore, the entire documentation is incomplete. Apart from this, the contextual information is missing so that none of the mentioned requirement can be fulfilled. This leads to the lead of new approaches for technical documentation.

2.2. Requirement specification

The previous findings lead to a technological demand for the plant manufacturer. The combination of different components in a virtual representation is necessary to develop an adequate software architecture. Booch et al. provide the following definition: „[...] an architecture is the set of significant decisions about the organization of a software system[...]“[7]. A software architecture assigns functionality to software components and describes them. To fulfill this demand, a software concept derived from the previous requirements has to be defined:

- flexible integration
- scalability
- platform with real-time performance and robustness

On the basis of the previously mentioned requirements for the provision of technical documentation, a flexible integration and variation of components has to be provided. A flexible integration is only possible by decoupled components. This leads to a high interchangeability. For the entire documentation, a data interchange format has to be chosen and a software architecture, divided into different layers, has to be introduced to build such a virtual representation. The demanded software architecture has to be scalable in order to handle increasing data traffic more