Self-adaptation and Pre-maintenance Strategy in Industrial Production

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Modern manufacturing systems consist of complex, heterogeneous and often distributed hardware components from a variety of vendors. The management of such systems has become more time consuming and requires expert knowledge typically only available from the system integrator. With the rise of Information Technology in the production floor of Industry 4.0, new solutions to these problems are becoming a reality. This new technology reduces the effort required for management of large production lines and provides new capabilities aiming to optimize their operation.

To meet the ever growing demands of industrial production, modern manufacturing systems must be capable of rapid product changes and product variations as well as maintaining a constant flow of production in order to reduce the associated costs. These complex systems consisting of heterogeneous collections of components often lack the important factors of ease of configuration and of a standardized management interface. The designer is faced with the problem of combining multiple components, from a variety of vendors that use their own proprietary software, in a single system that works in harmony. The European project PRIME [1] addresses this issue with the introduction of a multi-agent based framework.

In this framework each component is represented as an agent. Information about each agent can then be accessed in a generic manner. This approach offers a unified method for information retrieval which simplifies the process of creating a standardized Human Machine Interface (HMI) in the case of heterogeneous systems. The atomic skills of each component can be automatically detected and aggregated to build complex capabilities that encompass functionalities of one or more components. These advanced capabilities are compared to the product description for the system configuration to take place and replace or reduce the human effort required.

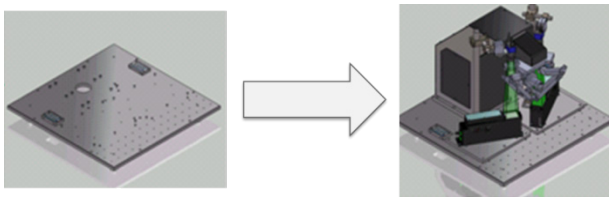

Figure 1: Demonstrator for system configuration. Image courtesy of Asyril [2].

A demonstrator (Figure 1) using an early version of the PRIME multi-agent framework has already been implemented [3] in collaboration with Asyril. Apart from the atomic skills that were used in this initial demonstrator component agents expose further information such as their status, execution times, and other measurements. This information can be processed with a variety of filters to provide real-time visualizations of historical data as well as prediction of future performance. Data from various sources can be combined to directly calculate Key Performance Indicators (KPI). These can be monitored and, once a predicted value falls under a certain level, a warning is issued and adaptation of the system can be performed.

CSEM in collaboration with ZHAW [4] is implementing a demonstrator that takes advantage of these capabilities of the PRIME toolbox. The demonstrator (Figure 2) is based on a rotary indexing table where ball bearings are initially fed into the system, processed by pneumatic grippers, inspected by cameras and finally unloaded from the table.

The table can move at one or two positions per step depending on the existence and performance of the hardware components. A smart HMI displays information about the connected components by unifying the heterogeneous hardware into a standardized view. The operator can focus on different levels of detail observing information about individual components or groups of them. By monitoring components, the system can detect if some hardware is underperforming, an indicator of possible failure in the near future. In such a case, a warning is generated for the operator and the system automatically adapts its configuration to avoid using the potentially malfunctioning component. Speed is reduced at one position per step and the system is self-adjusted so that the underperforming hardware can be removed for maintenance without having to completely stop the process.

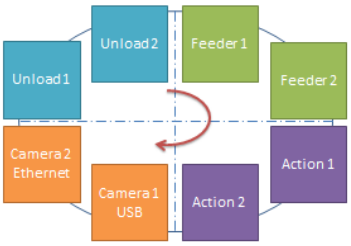

Figure 2: Diagram for rotary indexing table demonstrator.

This demonstrator utilizes the previous work on system configuration and extends it with the self-adaptation and pre-maintenance strategy. It offers a centralized management interface through the smart HMI that simplifies the process of operating a heterogeneous manufacturing system. With advanced process monitoring, proactive maintenance-schedule management can be performed in order to reduce the downtime of the system. This new strategy offers advantages in the optimization of complex assembly lines and aims to directly reduce the cost of such systems.

The work has been carried out in the collaborative project PRIME (University of Nottingham, Siemens, Simplan, TQC, Asyril, ZHAW, CSEM, UNINOVA, TTS, Introsys) supported by the European Commission under FP7, grant agreement number 314762. Co-financing by the EC and the cantons of Central Switzerland is gratefully acknowledged.

[1] www.prime-eu.com

[2] www.asyril.com

[3] I.Kastanis, *et al*., "Plug & Produce: Automatic detection and configuration of industrial devices", CSEM Scientific and Technical Report (2014), 110

[4] www.zhaw.ch