Chapter 109
Zero–Downtime Reconfiguration of Distributed Control Logic in Industrial Automation and Control

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ABSTRACT

Future manufacturing is envisioned to be highly flexible and adaptable. New technologies for efficient engineering of reconfigurable systems and their adaptations are preconditions for this vision. Without such solutions, engineering adaptations of Industrial Process Measurement and Control Systems (IPMCS) will exceed the costs of engineered systems by far and the reuse of equipment will become inefficient. Especially the reconfiguration of control applications is not sufficiently solved by state-of-the-art technology. This chapter gives an overview of the use of reconfiguration applications for zero-downtime system reconfiguration of control applications on basis of the standard IEC 61499 which provides a reference model for distributed and reconfigurable control systems. A new approach for the reconfiguration of IEC 61499 based control application and the corresponding modeling is discussed. This new method significantly increases engineering efficiency and reuse in component-based IPMCS.

INTRODUCTION

The decisive factor for the market success of the manufacturing industry (e.g. auto manufacturers and part makers, process industry etc.) is a fast and flexible reaction to changing customer demands—companies must show a high degree of changeability. New paradigms like “Flexible production up to small lot-sizes”, “Mass Customization” or “Zero-Downtime Production” will achieve these requirements but demand completely new technologies for its realization (European Commission, 2004). Changeability, which describes the ability

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of companies being flexible concerning customer demands, impacts all levels of product manufacturing. In particular these are the agility at a strategic level, the transformability at a factory level and the reconfigurability at the manufacturing system and machine level (Koren, 1999).

The state-of-the-art in manufacturing systems is inadequate to meet the above mentioned requirements. Current manufacturing systems are either tailored towards a specific product at high volume production and thus they can hardly be adapted to new products or they are flexible and programmable but technology specific and only for single item or small batch production. Another relatively new approach which is flexible and programmable but less technology specific but also hardly adoptable concerning the above mentioned requirements is the usage of "Multi Machining Technology Integration Production Systems" (Abele, 2005) which are characterized by the static implementation and combination of different technologies within one production system. The major drawback of this approach is that it is very resource consuming and therefore it can hardly be ported to small and resource constrained embedded controllers which are often used in modern industrial automation and control systems.

To reach the above mentioned changeability at the manufacturing systems and machine level it can be postulated that a change from product and technology rigid manufacturing systems towards product and technology flexible, modular, easy to setup component-based production systems is necessary. Following consequently this trend means that future plants will produce their products on manufacturing systems and machines which will be designed and setup just prior to production of goods since they are constructed on basic building blocks. Such building blocks are in general smart mechatronic components with embedded intelligence. These building blocks are designed in a way that they provide a specific manufacturing and/or automation functionality and they are not reconfigurable in general. Machining, assembly and transport systems of such production systems are also designed and set up by the utilization of various flexible autonomous and intelligent mechatronic components just before usage within the production line.

The consequences of the above mentioned attempt are extensive and many technological breakthroughs will be necessary. Beside others the development of an adequate automation system for heavily interacting distributed real-time systems can be seen as a major task. Current architectures of IPMCS do not conceptually support reconfiguration and distribution which are necessary to fulfill the requirements for the above mentioned systems (Sünder, 2006). Distributed embedded real–time systems for industrial automation and control of plants that evolve towards zero-downtime adaptable systems will play a key role to realize the roadmaps towards adaptive manufacturing (Koren, 1999) of products, goods and services in 2020. Most value will then be added in engineering and performing a system transition or reconfiguration (the change from one system state to another) rather than in engineering and performing "normal operation".

The challenge and aim of this chapter is to present an approach for modeling of reconfiguration control applications based on the IEC 61499 standard which provide an adequate engineering methodology for programmed system reconfiguration (i.e. system reconfiguration executed by a special control application). The first section discusses general reconfiguration issues. The next section gives an overview of state-of-the-art in reconfiguration of control applications. After that a summary of the main features and characteristics of IEC 61499 as the reference model for distributed automation and control systems with special focus of the management capabilities for reconfiguration is given. Furthermore an enhanced IEC 61499 Device Management is introduced which is used for the proposed approach for the controlled reconfiguration of control applications

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