Chapter 9
Product-Driven Control: Concept, Literature Review and Future Trends

Damien Trentesaux and André Thomas

1 Université Lille Nord de France, UVHC, Tempo-Lab., F-59313 Valenciennes France
Damien.Trentesaux@univ-valenciennes.fr

2 Research Centre for Automatic Control (CRAN), CNRS (UMR 7029), Nancy University, ENSTIB, 27 rue Philippe Seguin, 88000 Epinal, France
Andre.Thomas@cran.uhp-nancy.fr

Abstract. This chapter focuses on the concept of “product-driven control”. First, this concept is introduced and the expected advantages and the problems to be solved are described. A brief but representative state of the art is presented. Several product-driven control applications in different domains are also used to illustrate the concept. This paper concludes with a set of challenging prospects.

Keywords: product-driven control, holonic control, active product, intelligent product, product life cycle management.

1 Introduction

In the history of centralized approaches for production control, decision-making is hierarchically broadcast from the higher decisional levels down to the operational units. These approaches are successful, mostly due to their ability to provide long-term and global optimization of production planning and scheduling, given a relatively stable operational context.

Faced with the market challenges in the 1980s, other decision-making philosophies and strategies have emerged. Requirements for more and more reactivity and flexibility have led to Just-in-Time systems and, at that time, the implementation of first "distributed" approaches, such as anthropocentric and visual management methods (e.g., kanban systems, operator empowerment). In this period, the main idea was to react on the shop floor, immediately following a significant event. The workers were authorized to decide where the products have to go, because of the lack of adapted information technologies.

In the 1990s, Production and Supply Chain Systems have changed from the traditional mass production to mass customization in order to deal with the increase of the global market competition. High competition between enterprises and market volatility led to more agile enterprises [1]. A key issue was always the de-synchronization between material/physical and informational flows [2]. In centralized approaches, the time spent to inform the correct controller within the decision-making bottom-up hierarchy and then to decide and apply the decision in a top-down manner could
generate de-synchronization, as well as lags and instabilities. Despite their ability to provide near-optimal behaviour in fully static and deterministic environment, these approaches could not deal with disturbances easily and reactively and could not evolve with their environment. The constantly increasing power of the central calculator could barely deal with the complexity caused by these approaches.

Even though enterprise resource planning (ERP) systems are now widespread, these systems do not fully satisfy industrial needs. Industrial requirements have clearly evolved from the usual traditional performance criteria, described in terms of static optimality or near-optimality, towards new performance criteria, described in terms of reactivity, adaptability and visibility. A growing number of industrialists now want control systems that provide satisfactory, adaptable and robust solutions rather than optimal solutions that require the meeting of several hard assumptions [3]. Gradually the information technology improved, giving to the physical system entities (e.g., parts, resources) some decision-making capabilities and capacities in order to carry information. These improvements could be a new way to deal with this still unsolved problem.

Since the 1990s, more and more manufacturing systems control research has moved from traditional centralized approaches to more distributed architectures, allowing more self-organized and reactive control [4]. The concepts of Holonic Manufacturing Systems, Product-Driven Control Systems, Intelligent Products, Intelligent Manufacturing Systems, and Agent-Based Manufacturing, to name a few, have been proposed to design these future manufacturing systems. These concepts advocate that the products, and also, more globally, all the production resources, can be modelled as an association between two parts (i.e., a physical part and an informational part) to become a holon, interacting with human operators.

For all these distributed approaches, the common paradigm is bringing intelligence and autonomy as close as possible to the physical system, or even in physical system components. The idea was to permit the decisional entities to work and collaborate together in order to react quickly and autonomously within constraints, instead of requesting control decisions from higher decisional levels, which was generating response time lags. In these approaches, interaction processes other than coordination appear: negotiation and cooperation [5].

Faced with these new trends, much new research is focusing on identification and Auto-ID technologies, such as electronic or biometric technologies. Radio Frequency Identification technology (RFID) represents a quick and safe way to track products, opening the way to link informational and physical flows – which, as mentioned previously, still remain an important research challenge [2, 6] – and providing an accurate, real-time vision of the shop floor activities. Moreover, these new technologies appear as a catalyst to change the fifty years of the old ways of controlling production through traditional manufacturing resource planning (MRP2) systems.

Although there are many states of the art focusing on holonic or multi-agents production control, very few address the intelligent product (e.g., [7]). Among these states of the art, none addresses the control problem using intelligent products, or in other words, the way to control manufacturing or supply chain systems can be improved using product-based intelligent systems. Thus, the aim of this chapter is to describe the concept of Product-Driven Control (PDC) more precisely, the stakes (i.e., the expected advantages and the problems to be solved), and the relevant