Disturbance Detection, Recover and Prediction in Holonic Manufacturing Control

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***Abstract*—Disturbance handling is a crucial issue in the development of intelligent and reconfigurable manufacturing control systems, supporting the fast and promptly response to the occurrence of unexpected disturbances. In holonic manufacturing control systems, the disturbance handling functions are distributed by the several autonomous control units. In this paper, a predictive disturbance handling approach is presented, transforming the traditional "fail and recover" practices into "predict and prevent" practices, allowing improving the control system performance.**

I. Introduction

Industrial companies, to remain competitive, need to introduce agility and flexibility in their organization structures and production systems, facing the market demands and economy globalization. The current challenge is to develop collaborative and re-configurable manufacturing control systems that support small batches, product diversity, high quality and low costs. Holonic manufacturing systems (HMS) seem to be suitable to face these requirements, since they present decentralization of control over distributed structures, modularity, scalability, autonomy and component re-use.

Holonic Manufacturing Systems (see http://hms.ifw.uni-hannover.de/) translates to the manufacturing world the concepts introduced by A. Koestler for living organisms and social organizations [1], and is characterized by holarchies of holons, which represent the entire range of manufacturing entities. A holon is an autonomous and cooperative entity that may be made up of sub-ordinate parts and, in turn, can be part of a larger whole.

Industrial manufacturing systems are stochastic, dynamic and often chaotic environments, where new tasks arrive continuously to the system, and other scheduled tasks maybe cancelled, certain automation resources became unavailable and additional resources maybe introduced and unexpected disturbances may occur in the systems, such as machine failures, operator absence and rush orders. The occurrence of such unexpected disturbances leads to deviations from the initial and optimized plans, and usually degrades the performance of the system. It is even "proverbial among shop foreman that the schedules produced by the front office are out of date the moment they hit the (shop) floor" [2]. Possible consequences from the occurrence of disturbances are the loss of productivity and loss of business opportunities, which are crucial roles to achieve competitiveness.

In this context, the manufacturing control system should react quickly and promptly to unexpected disturbances, adapting its schedule plans as fast as possible, to improve the manufacturing control system performance. Thus, disturbance handling is an emergent topic associated to the development of intelligent and reconfigurable control systems, supporting the proper adaptation and response to the disturbance. In holonic manufacturing control systems, the disturbance handling is more difficult to implement than in the conventional manufacturing control systems, since they are distributed and event-driven systems. The disturbance handling functions should be embedded in each distributed and autonomous holon, that should be able to detect and recover autonomously from disturbance.

This paper intends to overview the needs of disturbance handling mechanisms in holonic manufacturing control systems. Besides the fault recover component, a special attention will be given to the prediction component, crucial to improve the reaction to emergence: if the system predicts the future occurrence of disturbances, the system can elaborate plans considering that occurrence, minimizing in this way its impact when it really occur.

Summarizing, the paper gives guidelines to the following relevant questions:

- How to detect the occurrence and determine the impact of disturbances?
- How to proper react to the occurrence of disturbances in order to minimize the impact and effects of it?
- How to predict the occurrence of future disturbances, based in the historical data?
- How to plan the future based in the prediction outputs?

The paper is organized as follows: first, Section 2 describes the predictive disturbance handling approach for

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