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Toward an implementation of recovery procedures for flexible manufacturing systems supervision

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Abstract

This paper first specifies Recovery and gives some trends about Recovery strategies. Then, it focuses on Reconfiguration. Several reactivity levels are defined according to the failure impact, flexibilities reserved during the exploitation phase, and flexibilities corresponding to the whole potentialities of the architecture. These enable to know if the FMS can react with its current configuration, or if its configuration has to be changed to go on with the production, or if the production has to be changed to maintain FMS availability. The Recovery procedures are implemented through a model named Operational Accessibility Graph, which has been emphasized by the definition of new attributes and methods. Some algorithms, based on the graph theory, are presented.

Keywords: Recovery; Reconfiguration; Graphs; Flexible manufacturing systems; Supervision

1. Introduction

Flexible manufacturing systems (FMS) are specific manufacturing systems. They are discrete event systems (DES) that include flexibility notion, which is characterized by the capability and the speed of adapting to new situations [1].

Our Supervision approach is different from the Supervisory Control [2,3,4]. Supervision is independent of Control Part. The aim of Supervision is to give parameters to the Control Part in order to perform, in the best conditions, production-planning [5]. Supervision fulfils functions like Monitoring, Piloting, and Working Modes' Management.

The architecture is supposed to be tolerant [6]. So, FMS has the potentiality to be reconfigurable. Control Part takes into account FMS flexibilities that are considered as potentialities in the set of possible controls. But the Control Part remains non-deterministic and does not decide about FMS configurations.

This paper focuses on Recovery and, especially, on Reconfiguration based on the hypothesis of complete failures.

It is organized as follows: After the definition of Recovery, including some strategies in Section 2, the modeling by operational accessibility graph is introduced in Section 3. New features emphasizing the model are also detailed in the this section. Section 4 refers to the model exploitation for Recovery and, especially, for Reconfiguration.

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2. Context

2.1. Definitions

Recovery notion of automatic field is a borrowed term from computer field. It comes from error recovery concept, first introduced by Laprie [7]. From the Control Part point of view, this notion induces several types of action:

- *Freezing and error confining*: Control is set in a state as it cannot propagate a diagnosed failure;
- *Resumption*: A Control procedure is established to enable to resume from the failure point;
- *Continuation*: Treatment is carried on from a point set after the suspended point;
- *Reconfiguration*: Control is reorganized to adapt itself to a new operating part configuration.

Recovery is classically considered as a monitoring function. It operates after the detection and the diagnosis of failures of some FMS elements. It establishes some strategies in order to maintain security and to increase the FMS dependability. In other words, Recovery determines the new state to be reach for the FMS. It decides about FMS resources and products present in the system. It provides service continuity with reduced performances after the failure of some FMS elements.

The implementation of such function often requires coordinate actions of Monitoring/Recovery, Working Modes' Management and Piloting modules (Fig. 1). The Working Modes' Management module has information about working states (Idle, Preparation, Production,...), and operating states (Normal, Degraded, Out of order) of each FMS level [8]. This module sets inactive the control of an out-of-order system. It also assumes the tactical reconfiguration by the management of transitional-resources states between the actual situation and the objective established by Recovery. Piloting module raises indeterminism left.

2.2. Hypothesis

The study is based on a deterministic and cyclic scheduling [9]. On a given horizon, for each part at the FMS entry is performed a temporal and spatial assignment of machining and transport resources. The path of each part in the FMS architecture is completely established at the entry. Piloting is of no use in this case.

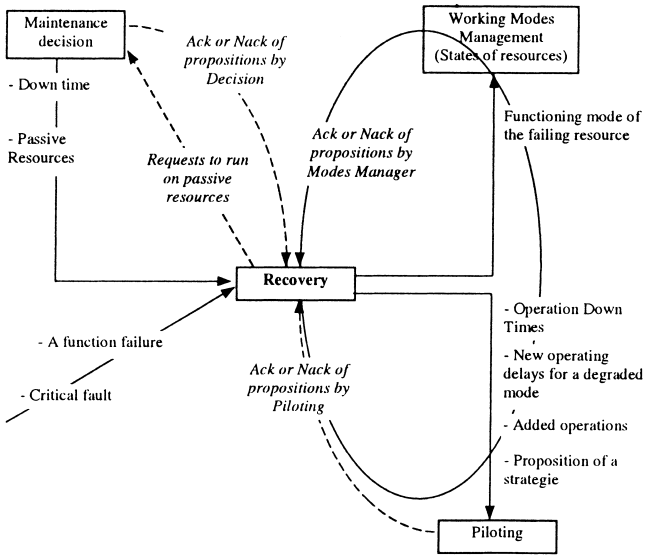

Fig. 1. Interaction between Recovery, Working Modes' Management and Piloting.