Switching between levels of Decision Making in MAS Organisation: application to flexible assembly cells

(Demonstration)

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ABSTRACT

This paper presents a bi-level multiagent organisation where decision-making are taken in an optimal way at the upper level of the MAS, and in a reactive way, at the lower level.

We proposed ORCA (Architecture for an Optimized and Reactive Control) approach to the management of flexible manufacturing systems. In this application, the upper level uses an Integer Linear Program (ILP) to allocate works to shuttles that have to build products; and the reactive scheduling model is based on potential fields.

A simulation allows us to test our models, before to implement them on a real flexible assembly cell and validate the simulation results.

Categories and Subject Descriptors

I.2.11 [**Distributed Artificial Intelligence**]: Multiagent systems

General Terms

Experimentation

Keywords

MultiAgent, MultiLevel Organisation, Manufacturing System

1. INTRODUCTION

The greater variety of products, the potential for large fluctuations in demand, the personalization of the demands are all challenges that manufacturing companies have to deal with to remain competitive. In this context, reactivity, robustness and adaptability of heterarchical control architectures are promising and match with the current constraints of the market. However the autonomous decisional entities (managing products, resources for example) that compose these architectures have some problems, as "myopia", i.e. a limited view in time and space due to their context that are defined as local.

Several level of cognition are so necessary, from a local to a more global control, or at least a more global perception of the system to control. In this context, this paper presents an application of the ORCA (Architecture for an Optimized and Reactive Control) approach, that we proposed, to the management of flexible manufacturing systems. In this application, the upper level uses an Integer Linear Program (ILP) to allocate works to shuttles that have to build products; and the reactive scheduling model is based on potential fields.

A simulation/emulation allowed us to test our models, before to implement them on a real flexible assembly cell and to validate the simulation results.

2. MANAGEMENT OF FLEXIBLE MANUFACTURING CELLS: A MULTI-LEVEL PROPOSAL

We proposed an Architecture for an Optimized and Reactive Control (called ORCA) to design multilevel distributed systems for flexible manufacturing cells management. ORCA is composed of three layers: *System Layer*, composed of entities directly linked to physical devices; *Local Control Layer*, composed of entities optimizing the working of a system entity "in a reactive way", i.e. by using bio-inspired or potential field approaches, for example; and a *Global Control Layer*, composed of entities that take strategical decisions for several 'local optimizers', or smaller 'global optimizers'.

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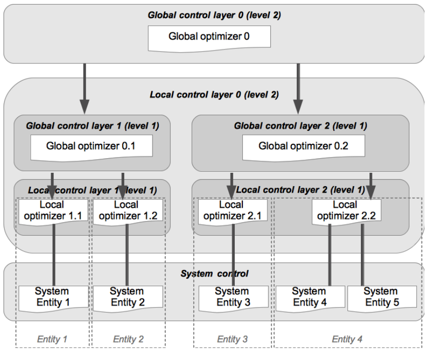

Figure 1: Example of ORCA application.

Figure 1 presents an example of application of ORCA to manage 4 physical devices (this implies 4 local optimizer), whose one (entity 4) is composed of 2 physical parts. In this example, the configuration leads to a separation of the global controls of the entities 1 & 2, and the entities 3 & 4. An upper level of global control is introduce to manage the coherence between the global control layers 1 & 2.

In our architecture, the entities can act autonomously, or as simple performers of a given plan; both of these behaviours can coexist.

In this paper, an application to the control of a real flexible manufacturing cell is given, entities represents self-propelled shuttles that transport products to the most adequate workstations. These entities follow first an optimal plan, computed by a ILP, but can switch to a reactive behavior, using potential fields, in case of perturbations.

3. FLEXIBLE ASSEMBLY CELL

In this section, we propose to illustrate (and reduce) the myopia phenomenon, when controlling the AIP PRIMECA FMS (Flexible assembly cell located at the university of Valenciennes). Figure 2 presents a picture of this Flexible assembly cell. The URL [http://www.univ-valenciennes.fr/sp/ActiveProduct/video_list.html] leads to videos of the AIP management with potential fields.

In our scenarios, products are created by shuttles identified by a RFID tag, that have to reach workstations (resources) that propose different actions, through a monorail and points. A shuttle, called 'Entity', is composed of a 'System Entity' (the physical device), and of a 'Local Optimizer' stored in a eeePC.

The production program consists of assembling four types of products ("b", "E", "L" and "T") which are different configurations of five components ("Axis-comp", "I-comp", "L-comp", "r-comp" and "Screw-comp"). The assembly cell contains several divergent nodes, allowing agents in the eeePC to choose between routes. The ORCA instance in this scenario is composed of two levels: **one global control layer** composed of one global optimizer, that use an ILP, solved using IBM Cplex 12.2 running on a PC with two processors and 1 GB of RAM, to compute the best distribution of tasks for the different entities; **one local control layer** composed of the different entities that are able to switch to a reactive behavior when an unexpected event occurs (addition of a new product order, fault in a workstation that becomes inaccessible).

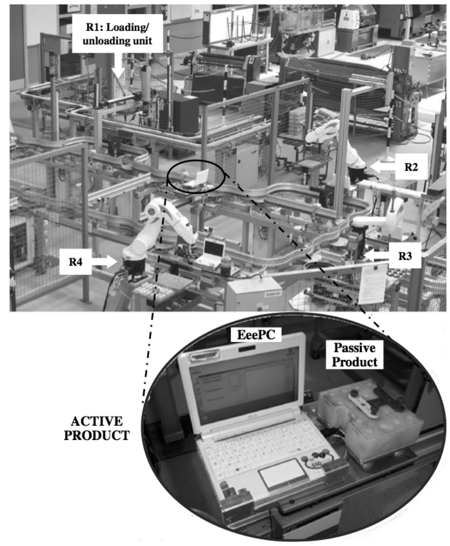

Figure 2: AIP : Flexible assembly cell

So, potential Fields are devoted to the dynamic routing and allocation processes; here, resources emit a potential field related to their attractiveness (the bigger the field, the more interesting becomes the resource) [1]. Fields are reduced if a product enters the resource or its waiting queue. Products sense the fields (through WiFi) when they reach a point. Each field is emitted for one service provided by the resource, so products have to focus on the fields related to the service they need.

To benefit both of the optimal planning (that needs one hour in our case to be computed), and of the possibility to adapt facing immediately to perturbations; our architecture ORCA propose to start the management of the manufacturing cell with entities acting with a no reactive behavior. As soon as an entity detect a perturbation regarding its own plan, only this entity switch to the reactive behaviour using potential fields. The entity go back to a no-reactive behaviour only at the end of the creation of its product, to receive a new processing plan to build a new product.

Simulations, based on NetLogo and Jade, are realized before implementing directly the ORCA solution on the flexible assembly cell; this allow to test several approaches of manufacturing cells management.

4. CONCLUSION AND FUTURE WORKS

The use of two level of control, optimal and reactive, bring interesting and efficient solution to the management of systems like flexible manufacturing cells.

Future works concern the use of ORCA to the management of other distributed systems evolving in dynamic environments (like planing and management of resources in emergency situations).

5. REFERENCES

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