Intelligent Automated Process: a Multi Agent Robotic Emulator

A. Gasparetto[1] and R. Vidoni[2] and P. Boscariol[1]

***Abstract*— The demands of modern industry push towards new adaptive and configurable production systems where multi-agent techniques and technologies, suitable for modular, decentralized, complex and time varying environments, can be exploited. In this work a generic assembly line is evaluated and the basic features, problems and non-idealities that can occur during the production are taken into account for evaluating and developing an intelligent automated process made of Multi-Agent Robotic Systems. A simplified agentification of the process is made: the main elements of the production are modeled as an agent while the operators that work to restock the local working station stores are considered as autonomous (robotic) agents.**

I. INTRODUCTION

Multi Agent Systems (MAS) have been extensively studied and applied in different fields such as electronic commerce, management and real-time monitoring of networks and air traffic management [1],[2]. The demands of the modern industry aim at creating configurable and adaptive production systems. Indeed, companies need a proper level of agility and effectiveness to satisfy the fast changes of customers' needs. Moreover, markets push manufacturing systems from a mass production to a mass customization fashion; a reduction of the product life-cycles, short lead times and high utilization of resources without increasing the costs are the main targets to satisfy. Thus, industrial needs seem to adapt well to the use of agent technology.

The MAS, in fact, are able to manage complex systems by dividing them into smaller parts and can react to dynamic environments. The main advantages of this technology and approach are: decentralized and distributed decision (i.e. each agent keeps decisions autonomously), and modularity of the structure (i.e. agents are independent). Hence, they are suitable for modular, decentralized, complex, time varying and ill-structured environments.

At today, their real application in plants and manufacturing systems is still an exception. This is not because they are not suitable for a real use, but because of a lack of confidence with such systems even if MAS technologies have been already evaluated and theoretically applied in different manufacturing sectors such as production planning, scheduling and control, materials and work flow management [3], [4], [5].

The purpose of this research is to adopt the intelligent agent techniques to study and develop a distributed framework in order to emulate an industrial robotic process and a chain production activity.

[1]DIEGM, University of Udine, Via delle Scienze 206, 33100 Udine gasparetto@uniud.it, paolo.boscariol@uniud.it

[2]Faculty of Science and Technology - Free University of Bozen-Bolzano 39100 Bolzano, Italy renato.vidoni@unibz.it

II. PROCESS AND PRODUCTION LINW

In this attempt, the simulation and emulation of a a mixed-model mass production line are considered. The process is implemented with a pull logic and the supply chain management relies on the Just-In-Time (JIT) techniques. The resulting product is a household appliance, which bill of material has been simplified to facilitate the emulation. Since the product is generic, it can be easily adapted to any production field.

The objective of this research is to create a system able to manage autonomously the lowest level, making the assignment of tasks to the automatic machines. In such a phase, the autonomous agents system must be able to establish, without a centralized control, the better division of the required production, even if there are not the predicted conditions in the line (e.g. if materials in the warehouse are missing).

III. MODEL OF THE EMULATOR

The mixed-model line has been chosen since it allows to change in the mix of produced models without having to perform expensive set-up operations. In such a way, an easy adaptation to fluctuations in demand without excessive stocks of finished goods is admitted. A series of routine operations are usually carried out and, depending on the model, only some product features are modified: in the implemented model each machine has different components but the same production cycle.

The appliances in production are brought automatically from one machine to another at the end of each process, and to the store. In Fig. 1 the structure of the emulator, i.e. machines, components warehouse, stores, robots and suppliers is presented.

IV. MULTI AGENT ROBOTIC SYSTEM

The production line model is managed through a system based on multi-agent technology. The following autonomous agents have been implemented:

- *Scheduler agent*. It calculates the size of the lots and schedules the production over time. It sends the lots size to the *Station agents* and instructs the *Robot agent* on what has to be ordered to finish the production.
- *Station agent*. One for each station: it receives the requests to produce the lots from the *Production agent* (only the station number 1) or previous *Station agents* and sends requests to the next stations. Station agents are in charge of controlling the number of available

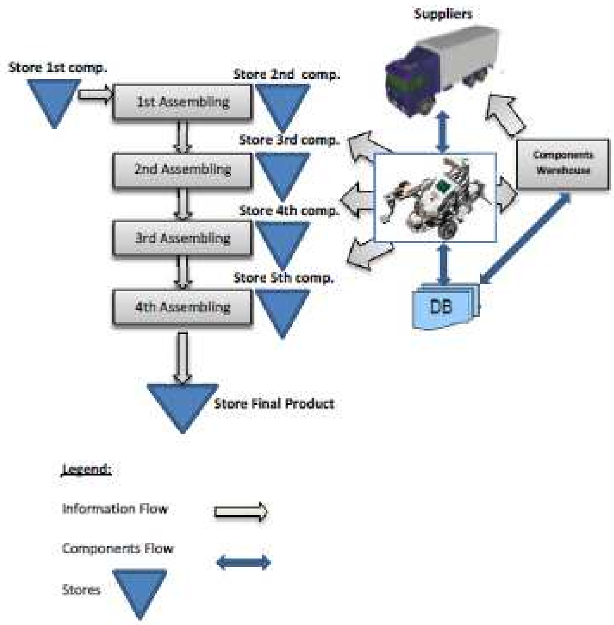

Fig. 1. Model of the process

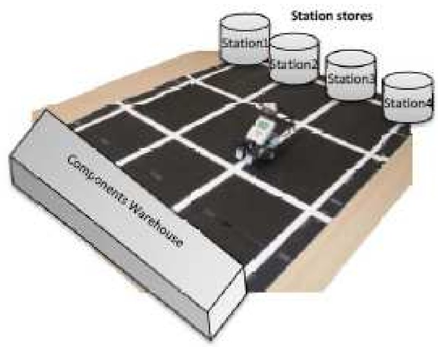

Fig. 2. NXT Robots and environment

pieces and, if necessary, of ordering the lacking components to the *Robot agent*. For each assembly produced, the related components are decremented.

- *Production agent*. It receives requests and sends them to the first station of the line to start production. It informs the *Scheduler agent* when the production of a lot has been completed.
- *Robot agent*. It receives from the *Station agents* the requests of components delivery and is responsible of guiding a robot to and from the warehouse for the withdrawal of materials. If components are missing, it sends requests to the *Supplier agent*.
- *Supplier agent*. It receives from the *Robot agent* requests for supply components and sends the time needed to fill in the warehouse. When the delivery time is up, it takes care of adding the required parts in the warehouse. If the material is wrong restarts the time and sends a negative response. It chooses the external supplier evaluating its performances.
- *External supplier agent*. It receives requests for parts availability from *Supplier agent* and answers by sending its parameters. If this supplier is chosen, it receives the supply order and sends its time.

V. EMULATOR STRUCTURE

Agent technology has been standardized thanks to the efforts of the Foundation for Intelligent Physical Agents (FIPA). Indeed, it has developed specifications for permitting the spread of shared rules that have brought to the development of FIPA-OS (FIPA-Open Source), JADE (Java Agent Development Environment) and ZEUS agent platforms, all compliant to the FIPA rules and directives [6]. Three main flows characterize the emulator:

- the flow of information exchanged between the various autonomous agents.
- the flow of information of the product within the production line.
- the flow of information of the components between the warehouse and the machines, carried by the robots

The chosen hardware to create a realistic simplified scenario is the Lego Mindstorms NXT, shown in Fig.2.

VI. CONCLUSIONS

In this work a generic assembly line has been evaluated and modeled in order to take into account the basic features, problems and non-ideality that can occur during the production. An intelligent automated process made of Multi-Agent Robotic Systems has been evaluated and studied. A simplified agentification of the process has been made, each working station, external supplier and main elements of the production has been modeled as an agent. Operators that work in order to restock the local working station stores have been considered as autonomous (robotic) agents.

The overall framework has been realized and an emulator has been implemented by means of the JADE platform, that follows the FIPA standards, and NXT-robots.

REFERENCES

[1] Wooldridge, M., *An introduction to multiagent Systems,* Ed. John Wiley & Sons, UK., 2002

[2] Bussmann, S., Schild, K., *An Agent-based Approach to the Control of Flexible Production Systems*, Proceedings of the 8th IEEE International Conference on Emerging Technologies and Factory Automation, Vol. 2, 481-488, 2001

[3] Pechoucek, M., Mark, V., *Industrial deployment of multi-agent technologies: review and selected case studies*, Autonomous Agents and Multi-Agent Systems, Vol.17/3 , Kluwer Academic Publishers Hingham, MA, USA, 2008

[4] Caridi, M., Sianesi, A., *Multi-agent systems in production planning and control: An application to the scheduling of mixed-model assembly lines*, International Journal of Production Economics, Vol.68, 29-42, 1999

[5] McMullen, P.R., Tarasewich, P., *A beam search heuristic method for mixed-model scheduling with setups*, International Journal of Production Economics, Elsevier, Vol.96/2, 273-283, 2004

[6] Bellifemine, F., Caire, G., Poggi, A., Rimassa, G. *ADE: A software framework for developing multiagent applications*, J Lessons learned. Information & Software Technology, Vol. 50/1-2, 10-21, 2008