The Migration from Conventional Manufacturing Systems for Multi-Agent Paradigm: the First Step

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Abstract. The consumer market ever more calls for diversified products in small batches and the industry lacks production systems that meet the demands with efficiency and ability to adapt quickly. Integrated manufacturing systems implemented have their management for programmable logic controllers and electrical interconnections, control logic and satisfactory robustness, but they do not attend the needs of diversity and flexibility in production. The solutions to these needs refer the company to migrate to the use of new technologies of control, circuit and logic. But, for an industry migrates is a very big and expensive step. Then, there is an urgent need for methods that implement the interface between logic controllers and multi-agent systems in order to evolve an integrated manufacturing system taking advantage of all electrical circuitry, control logic and the logic controller that installs itself, taking advantage of the self-adapting characteristics that the multi-agent systems provide.

Keywords: multi-agent systems, industrial manufacturing, agility, self-adaptive systems.

1 Introduction

The modern consumer behavior is in constantly changing and the industry is facing the big challenge of accompanying these changes. On the one hand, consumers are seeking ever more customized products which represent their individuality, on the other hand, the industry, to remain competitive, needs to meet this demand of large-scale variety.

The study of James [1] has pointed out that the business environment in the future would be characterized by constant changes in market demand and the global competitiveness would push the entry of new products.

The high-volume production continues to be processed however, as pointed out [2], there is a tendency to mass production of highly customized product. And it leads to a large volume of small lots. And the speed that the market demands products highly customized to be delivered is important. The production line space to adapt to a new product is smaller and significant to the final cost. As stated in [3], to cope with this new reality and achieve a competitive advantage over competitors, future productions systems must provide solutions to: long time for system design, commissioning and

setup; complex variations requirements; inflexible implementations; scalability; fault-tolerance or redundancy; and incompatibility between different technologies.

But, what method it is necessary to industries will migrate to new paradigms that attend the market requisites? One cannot simply dismantle the existing production systems and build new ones, with new paradigms. This work will be discussing the steps to migrate from a conventional manufacturing to a system self-adaptive, making use of all existing infrastructure and local logical.

This work shows a study of manufacturing industrial and the possible solution for new necessities of market. In section 2 approach how could-based can be used for support to self-organized systems. The section 3 shows de concepts of industrial manufacturing management. The section 4 shows the approaches this problematic by academics and researches groups. The section 5 discusses a need of method to migrate of conventional system to self-organized systems. And section 6 shows the conclusion of this work.

2 Contribution to Cloud-based Engineering Systems

The requirements of diversity in production lead the industry to need versatile systems that use shared resources. One way is to share resources through Cloud-based. This concept computing systems applied in manufacturing, such as multi-agent systems, recourse to cloud environments to seek methods, algorithms, and means for obtaining a skill required by a new production process that is presented. The multi-agent systems need not have all the variants of a production process to serve it with the diversity it needs, just to have these variants seek in a cloud environment, sharing resources with all agents in the system.

With the computing resources evolution available to the manufacturing management, solutions using the "cloud" concept have emerged as a good alternative to systems which have high power of communication, but do not have elevated power to local processing. In [4] the application of multi-agent solutions with cloud systems is approached and can be seen in Figure 1.

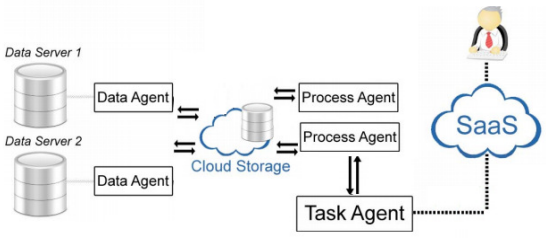

Fig. 1: Mult-agents using cloud concept, based on [4].

In Figure 1 the Process Agents resorting to the cloud environment (Cloud Storage) to obtain data on the process as well as the Task Agent resorting to cloud environment (SaaS) to learn skills with humans.

3 Manufacturing Systems Management

The management system has been constantly the subject of research and to every new demand that arises new paradigms are researched and implemented. This work mentions what it thinks to be the most significant in terms of solution presented to industry.

3.1 Management with Programmable Logic Controllers (PLC)

Manufacturing system has evolved from craft production with low volume, high variety and general purpose machines to production lines, dedicated machines and large enterprise, which enable the mass production [5]. Mass production brought the concept of a manufacturing with a viewpoint centered on Programmable Logical Controllers (PLC), which operates in a loop: (i) read all inputs; (ii) execute defined logic (the process) to generate the outputs from the inputs; (iii) trigger the outputs conform the processing logic;

3.2 Flexible Manufacturing Systems (FMS)

For the same equipment being able to perform more than one operation in manufacturing, it should be resourced to enable, through feeding device, change its functionality, providing distinct processes to be performed by the same equipment. A FMS is distinguished from other forms of automated manufacturing by considering the diversity of the products they want to produce (product flexibility) and adaptive characteristics of the machines (flexibility of the equipment) [6] e [7];

3.3 Computer Integrated Manufacturing (CIM)

CIM is a concept where the approach aims at integrating all process stages: sales, supplies, design and development, production and delivery. The paradigm is the integration of all the company activities through the use of information technology [8], such as databases, networks, etc., that allows the data exchange and sharing between business units and its applications. Computer integrated manufacturing is the efficient use of information technology in manufacturing to increase productivity and efficiency of businesses;

3.4 Evolvable Assembling Systems (EAS)

EAS are the integrated systems with equipment that allow modularity, adaptability and scalability of the product. They are modules who should provide open hardware and software architecture with plug and play functionality; the connection is made without the other equipment being disconnected or reconfigured. The reconfiguration of systems allows the manufacture to be evolvable. The mounting system of the evolution is based on simple systems, reconfigurable elements with specific tasks (system modules), which allow a continuous evolution of the system. An EAS can co-evolve with the product and assembly process [4]. The EAS can be implemented by Service Oriented Systems (SOA), that is the basic element in the abstraction of

services which has properties of autonomy, interoperability, platform independence, encapsulation and availability [9], or by using Multi-agent Systems (MAS) defined as a paradigm derived from the distributed artificial intelligence field, characterized by decentralization and parallel execution of activities based on autonomous entities, called agents [10].

The table 1 shows a comparison among the proposed manufacturing management system, linking the paradigm employed, the main feature and the ability to use cloud approach.

Table 1. Comparison among the systems of manufacturing management.

Management system	Paradigm used	Main Feature	Cloud Solutions
Centralized	Logic control	All control of process	-
FMS	Logic control	Idle resources	-
CIM	Computer control	Require availability resources	Possible
EAS	SOA or MAS	Adaptation to manufacturing required	High

4 Approaches to New Paradigms for Manufacturing

4.1 Academic Approaches

The self-organizing systems researches are increasing, but there are still few studies with real industry application. But the fact the academics take care of this problem is a big step to find new forms of applying concepts and get new solutions. The table 2 shows some research in doctoral thesis that approaches the topic.

Table 2. Comparative approaches in academic research.

Ref.	Problematic	Method	Application
[11]	Need for agility on the factory floor to handle disturbances and uncertainty	Multi-agent systems for interface between generic and physical environment	Integrated manufacturing plant with 2 robots
[12]	Properties of self-x to implement self-organizing systems	Product fits into modules, forming coalitions, generating optimized layouts	Plant with 3 robots, 5 conveyors, and 3 parts feeders
[13]	Diagnostics in complex industrial installations with a large number of components	Agents make the diagnosis of component failure and estimate its propagation	Manufacturing plant with 2 coveyors, 2 robots and pallets
[14]	Attending the diversity production requirements to market demands	Agents in layers, one for deliberation and one for rapid reaction	Manufacturing cell with axis of rotation and translation
[15]	Replace the component automation interconnected with distinctive technology	Converting the functionality of a device existing in a service offering	Plant with 2 dosage machine and 1 transport line
[16]	Necessity of use dynamic allocation of resources to changing production	Situation analysis, objectives and adaptation of system behavior	Implementation of power drives using MatLab

[17]	Production attend a series of small lots, sometimes a unique lot of one product	Defines a semantic link among the concepts of agent, environment and organization	Production line for small series of assembling boards
[18]	Attending to the rapidly changing needs of the consumer	Each agent met together in order to form a productive arrangement	Case study in industries to support decision making

Among the studies reported can be seen that the problems are similar, the methods are different and the results refer to the same path: industrial manufacturing. Thus, the academy has solutions by attend the need of industry to diversity of market demand.

4.2 Project Groups

The multi-agent paradigm systems used in industrial manufacturing has been the subject of research projects, sometimes there is in the group companies tendency to apply these concepts. This interest demonstrates this topic importance, and the fact of industry assumes that it finds solution to varieties of products required by the market. The table 3 cites some project groups who work among with companies and research institutes. These groups are predominating in Europe when the topic is more development in research and industries appliance.

Table 3. Groups of projects that approaches multi-agents systems in industrial manufacturing

Project	Referencies	Approach	Some Partners
SOPRO	[19]	Self-organizing systems	Fraunhofer IZM
COSMOS	[20]	Self-adapter of product variance	UNINOVA, Phoenix Contact, OST, EDAG
EUPASS	[21]	Self-integrated modules of flexible production	UNINOVA
IDEAS	[22]	Self-adapter to changing of technologies components	UNINOVA, Nottingham University, FESTO, KTH, MASMEC
XPRESS	[23]	Design of production based on self-organizing.	University of OULU, Fraunhofer, Airbus, KUKA.
PRIME	[24]	Plug-and-produce systems in self-organizing concepts	UNINOVA, Siemens, Nottingham University, Introsys, Asyril, TQC, Simplan

Here it's possible to observe the importance of the self-organizing for central researches and manufacturing industries.

4.3 Gaps among Approaches

The cited approaches, either in theses either for research groups indicate solutions to the need of quickly respond the change in the product industry, but they point the way to the deployment of a new technology. Considering the industry has controllers installed, mounted with their hardware and their defined logic locations, the proposed solutions do not take advantage of it, which is present on the factory floor.

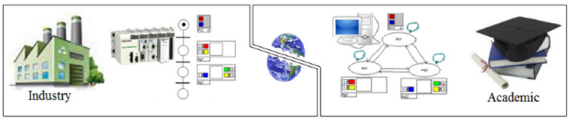

Fig. 2 Paradox between the current technologies installed in industry and solutions that academics offer, two would with different approaches.

And this is a big gap in application terms, it is a fact that the industry does not want to eliminate the controllers they have and with known characteristics. But one needs to migrate to new concept, because of what not answers the new demands of the market. This is the paradox the academy is responding and has been a big gap to be studied and resolved.

5 Discussion of a Method to Migration

The solutions proposed by academy to attend the need of self-adaptation with multi-agent systems require computer systems with high capacity, which makes the controllers that manage machines today in the industry, do not support this technology. But abandoning these controllers seems, in the industry eyes of the something unacceptable face every investment already made in installation.

The Figure 3 shows the first step proposed for migration.

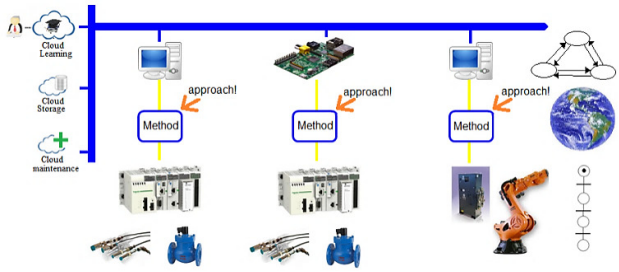

Fig. 3: Proposed migration from the existing system of automation to self-adaptive systems

For the industry to join the new paradigm will require several intermediate steps. And the first step is to develop a method that can migrate the conventional management system for managing a multi-agent system.

The method can be abstract the functionality of a controller existing in an envelope, disposing in the multi-agent system to supply and request services, beyond the capability of interaction and negotiation. The method will have to define how to access controller existing, which can be learned by agents assigned in the cloud (cloud learning).

Inspection requirements and the database can also be modeled in the cloud, in order to provide specifications of the items that should be targeted in specific

manufacturing agents (cloud maintenance) and storage of knowledge about the colligations system to attend a specific demand (cloud storage).

The method under discussion must then be connected in a multi-agent platform and interfaced with the hardware controller by one communication form, translate the features of each station in services and their needs must be translated into requests.

6 Conclusions and Future Work

Market demand is a reality that the industry must attend and that this work has examined solutions that academic and research groups had presented and took part in proposing an intermediate method between the management of current and future manufacturing. A conclusive research that refers to a method that helps to evaluate a management system for logic controller to migrate to a multi-agent platform is something wanted by the industry as the first step to adherence to new paradigm.

Once the first step is given, more multi-agent systems begin to work in and more results will be reviewed and for directing the path. As future work this paper suggests the implementation of methods that interfacing existing controllers on the factory floor with management modules of the agent in order to abstract functionality. These methods may be validated and defined its comparison of efficacy. Also suggests the search of agents that act in the cloud and can support maintenance inspection.

References

1. James F.; Smit, H. Service-oriented paradigms in industrial automation. IEEE transac-tions on industrial informatics, Nova York, v. 1, n. 1, pp. 62-70. (2005)
2. Herrera, V.; Bepperling, A.; Lobov, A.; Smit, H.; Colombo, A.; Lastra, J.Integration of Multi-Agent Systems and Service-Oriented Architecture for industrial automation. Proceedings… IEEE International Conference on Industrial Informatics, INDIN 2008. 6th: Daejeon. pp.768-773. (2008)
3. Cândido, G.; Colombo, A.; Barata, J.; Jammes, F. Service-oriented infrastructure to support the deployment of evolvable production systems. In Proceeding… IEEE Transactions on Industrial Informatics, [s.l.]: IEEE ,v. 7, p.:759–767. (2011)
4. Othmane, B.; Hebri, R. Cloud computing & multi-agent systems: A new promising approach for distributed data mining. International Conference on Information Technology Interfaces (ITI), Proceedings… the ITI 2012 34th. IEEE: Oran, Algeria, pp.111-116. (2012)
5. ElMaraghy, H. Flexible and recongurable manufacturing systems paradigms, In…International Journal of Flexible Manufacturing Systems v.17. pp 261-276. (2005)
6. Peixoto, J., Pereira, C., Cavalcante, A. When agents meet manufacturing: paradigms and implemations. In: XIX Brazilian Congress of Automatic – CBA2012, Campina Grande. Proceedings… Campina Grande: [S. e.]. pp. 957–964. (2012)
7. PEIXOTO, J. A. Development of manufacturing automation systems using service-oriented architectures and mult-agents systems. 2012, 134 f. Dissertation of Master Degree – Electrical Engineering Department, Federal University of Rio Grande do Sul - UFRGS, Porto Alegre, (2012)
8. Leitão, P.; Barata, J.; Camarinha-Matos, L.; Boissier, R. Trends In Agile And Co-Operative Manufacturing. In: Low Cost Automation Symposium - LCA, Berlin. Proceedings… Berlin: IFAC. pp. 156-165. (2001).

9. Ribeiro, L.; Barata, J.; Colombo, A. MAS and SOA - A Case Study Exploring Principles and Technologies to Support Self-Properties in Assembly Systems. Second IEEE International Conference on Self-Adaptive and Self-Organizing Systems Workshops (SASOW), pp. 192-197. (2008)
10. Leitão, P. Agent-Based Distributed Manufacturing Control: A State-Of-The-Art Survey. Engineering Applications of Artificial Intelligence, vol. 22, issue 7, pp. 979-991. (2009)
11. OLIVEIRA, J.A.B. Coalition based approach for shop floor agility–a multiagent approach. 2004. Dissertation for PhD degree in Electrical Engineering – Faculty of science and technology , University Nova de Lisboa, Lisboa, 2004.
12. FREI, R. Self-organisation in evolvable assembly systems, 2010, 250 f. Dissertation for PhD degree in Electrical Engineering – Faculty of science and technology, University Nova de Lisboa, Lisbon, (2010)
13. Ribeiro, L. Diagnosis in Evolvable Production Systems, 2012, 230 f. Dissertation submitted for a PhD degree in Electrical Engineering – Faculty of science and technology , University Nova de Lisboa, Lisbon (2012)
14. CAVALCANTE, A.L.D. Agent-based and self-organizing architecture for manufacturing. 2012. Theses of Doctor Degree - Electrical Engineering Department, Federal University of Rio Grande do Sul - UFRGS, Porto Alegre, (2012)
15. Cândido, G. M. Service-oriented architecture for device lifecycle support in industrial automation. 2013. Dissertation for PhD degree in Electrical Engineering – Faculty of science and technology , University Nova de Lisboa, Lisbon, (2013)
16. OBERTHÜR, S. Towards an RTOS for self-optimizing mechatronics systems. 2009, 147 f. Dissertation submitted for a PhD degree in Electrical Engineering, Paderborn University, Paderborn, (2009)
17. ROLOFF, M. L. A New Approach for Implementing Multiagent Systems for the Production Control in Small Series. 2014, 294 f. Thesis of Doctor Degree in Automation and Control Engineering, Federal University of Santa Catarina, Florianópolis, (2014)
18. Peschl, M.: An architecture for flexible manufacturing systems based on task-driven agents. 2014. Thesis to Doctoral program – Faculty of Information Technology and Electrical Engineering, Oulu University, Finland, (2014).
19. SOPRO Project - Self-Organizing Production, http://www.izm.fraunhofer.de/en/abteilungen/
20. COSMOS Project – Flexible Modular Automation , http://www.cosmosproject.eu/
21. EUPASS Project – Evolvable Ultra-Precision Assmbly Systems, http: http://cordis.europa.eu/result/rcn/51017_en.html
22. IDEAS Project –Instantly Deployable Evolvable Assembly Systems , http://www.ideas-project.eu/
23. XPRESS Project - Flexible production experts for reconfigurable assembly technology, http://www.xpress-project.eu/
24. Prime Project - Plug and Produce Intelligent Multi Agent Environment based on Standard Technology, http://www.prime-eu.com