Integration of Business and Manufacturing Processes through Industrial Machinery as a Service Approach

Virgilio Gilart-Iglesias, Francisco Maciá-Pérez, Diego Marcos-Jorquera,
Francisco J. Mora-Jimeno and Juan A. Gil-Martínez-Abarca
Computer Science Department
University of Alicante
San Vicente del Raspeig. Spain
{vgilart, pmacia, dmarcos,fjmora, gil}@dtic.ua.es

Abstract— **In manufacturing organizations is difficult to reach the requirements of the new business models (agile and dynamic adaptation to changes) due to technological and conceptual constraints between elements located at different levels of the organization, which prevents the integration of business and manufacturing processes. In this paper, a new industrial machinery model that achieves this integration has been proposed. This model, named IMaaS, shows the industrial machinery as a set of business processes, removing the conceptual constraints, and exposed as services, removing technology constraints.**

Keywords-BMP, SOA, Manufacturing Processes

I. INTRODUCTION

The new business models, oriented to mass customization, claim to the organizations new production models, more dynamics and flexible, that may become adapted, in agile way, to the environment changes due to the market demand [1]. In order to respond to the needs of the new business models, a new paradigm named BPM (*Business Process Management*) has emerged [2].

However, to achieve the viability of the new business models in the manufacturing organizations is a complex process, because there is not a full integration due to physical, technological and conceptual constraints and the lack of standards in production devices [3].

The main and most novelties integration proposals of business and manufacturing processes are focused on using of SOA paradigm and WS technologies in the production levels [3] [4]. However, these proposals focus on achieve the technological integration, but do not take into account the conceptual integration of both processes, avoiding an integral management according to the requirements of new business models. In order to achieve such full integration, in this paper a model, called *Industrial Machinery as a Service* (IMaaS), is proposed. This model adapts, both conceptually and technologically, the manufacturing processes and its management to the field of business processes, showing industrial machinery as part of a BPMS and technologically supported by the SOA paradigm.

To remove technological constraints on the manufacturing lower level two processes were proposed [5], a physical normalization process that provides industrial machinery of computation and communication capacities and, a middleware normalization process that show industrial machinery as a services container that provides the appropriate infrastructure, in terms of middleware services, to the application services. This work focuses on the detailed description of the process that removes the conceptual constraints, *the service normalization process*.

The remaining of this paper is organised as follows: section II focuses on service normalization process; section III describes a test scenario to validate the proposal; finally, in section IV, conclusions are exposed.

II. SERVICE NORMALIZATION PROCESS

To remove existing conceptual constraints, the *Service Normalization Process* shows the industrial machinery as part of BPMS through the *Industrial Machinery BPM Pattern*. The pattern functionality is exposed as services by means of SOA paradigm and WS technologies, allowing that manufacturing processes can be modified in an agile and flexible manner, aligning them with the changes in the strategic business objectives.

A. Industrial Machinery BPM Pattern

To develop the pattern, a process divided into two phases has been defined. In the first phase, a categorization of the business processes included in the industrial machinery has been made, showing the industrial machinery as a set of business processes (*Industrial Machinery Business Processes Map*). This model has been divided in three levels. At level 1, the business processes that execute the activities of higher abstraction level of industrial machinery have been considered. *Level 2* is composed by the business processes that make up the business processes defined in the level 1, and can be divided, in reiterative way, in another processes included in the level 2. In the level 3, basic activities are included. These activities encapsulate the lowest behaviour level of the industrial machinery, and therefore, the behaviour closer to the mechanical functionality of industrial machinery.

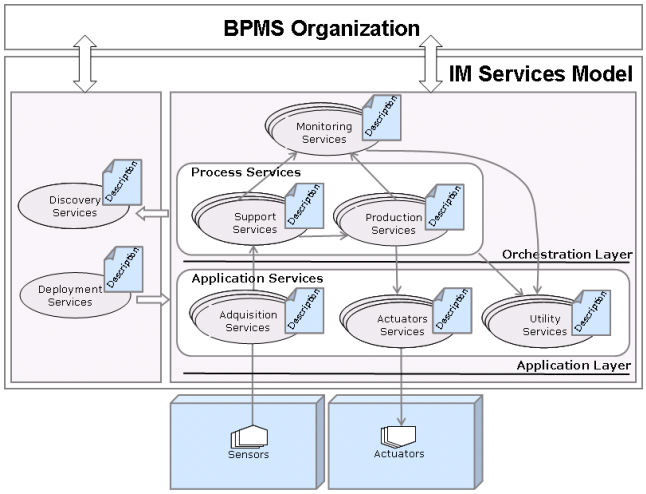

Figure 1. Industrial machinery service model.

In the second phase, once defined the *Industrial Machinery Business Processes Map,* the elements that allow achieving the necessary principles of the BPM paradigm [2], in order to get an integral management together with the remaining organization processes, have been defined. These elements are: *Discovery System, Execution Processes System* and *Monitoring* and *Control System.*

B. *Converging with SOA Approach*

The objective of this phase is to expose the functionality defined in the conceptual model of BPM as a service by obtaining a technological vision of the model similar to the items located on the upper levels of the organization (fig. 1). This approach distinguished three different kinds of services in the application layer of industrial machinery: *Process Services, Application Services* and *Management Services*.

Process Services are orchestrated services that expose the higher level functionality of the industrial machinery. These services are divided in: *Production Services* which represent industrial machinery core business processes and *Support Services* which encapsulate the necessary business logic in order to assure the execution of *Production Services.*

The *Application Services*, located in the application layer, expose the basic functionality that will be reused by other services. These services are divided in: *Acquisition Services* which expose the necessary functionality to read the information provided by the industrial machinery sensors; *Actuator Services* which expose the basic industrial machinery functionality of the mechanical components; and *Utility Services* which are general purpose reusable services.

Management Services expose the necessary business logic to manage the process exposed by the service defined previously. *Management Services* are divided in three kinds of services: *Discovery Service* which exposes the industrial machinery functionality to the BPMS; *Monitoring Services* which expose the functionality of control and objectives supervision correlated to the business processes; and *Deployment Service* which exposes the functionality that permits deploying new services on the industrial machinery.

III. TEST SCENARIO AND VALIDATION

To validate the integration capability (conceptual and technological) of proposed model, we have deployed a SOA scenario based on *Match-Maker pattern*, which includes different business and manufacturing processes used in manufacturing organizations. To implement a prototype several elements were used or developed: a scaled model of an industrial plant constructed by the *Staudinger GmbH* company; several embedded devices *Lantronix XPort* which dotting the machinery of computing and communication capacity necessary to support the WS-* middleware; an UDDI registry (Apache jUDDI v3) that contains the necessary information to consume the services offered; Intalio BPMS Community Edition version 6.0; and we have developed a Eclipse plugg-in to discover, upgrade and deploy services automatically in the industrial machinery.

For the experiments, we have focused on the storage process, carried out by IMaaS intelligent warehouse prototype (*StoreRawMaterial* and *GetRawMaterial*), and its integration with dependent business processes like inventory management, order management and production planning.

IV. CONCLUSIONS

In this paper, an industrial machinery model has been proposed, allowing an integrated management according to the requirements of new business models. In particular, the process that eliminates the conceptual constraints through services normalization has been further developed.

ACKNOWLEDGMENT

This work was supported in part by the *Vicerrectorado de Investigación, Desarrollo e Innovación*, *University of Alicante* (Proyectos de investigación emergentes 2010: Sistema de gestión de procesos integral en entornos manufactureros. Aplicación a la fabricación ágil).

REFERENCES

[1] C. Younghwan, K. Kwangsoo, K. Cheolhan. "A design chain collaboration framework using reference models," *International Journal of Advanced Manufacturing Technology*. 26 (1) pp. 183-190. July, 2005.

[2] H. Smith and P. Fingar. *Business Process Management. The Third Wave.* Meghan-Kiffer, 2002.

[3] F. Jammes, H. Smit. "Service-Oriented paradigms in industrial automation," *IEEE Transaction on industrial informatics*. VOL I. nº 1, pp. 62-70. 2005.

[4] Moreira, L., Spiess, P., Guinard, D., Köhler, M., Karnouskos, S. and Savio, D.: SOCRADES: A Web Service Based Shop Floor Integration Infrastructure. The Internet of things, LNCS, Vol. 4952, pp. 50-67, Springer Berlin, 2008.

[5] V. Gilart-Iglesias, F. Maciá-Pérez, J.A. Gil-Martínez-Abarca and A. Capella-D'alton. "Industrial Machines as a Service: A model based on embedded devices and Web Services". *Proceedings of 4th International IEEE Conference on Industrial Informatics.* Singapore, 2006.