A service oriented architecture to support industrial information systems

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Abstract. In order to fulfill economical constraints, enterprises are more and more involved in collaborative organizations. To develop such co-industry frameworks, a particular attention has to be paid on enterprises organisation and on the common information system. To provide the required agility level involved by such lean collaborative organizations, one may use a Service Oriented Architecture to support the information system infrastructure. Despite of its intrinsic flexibility and openness (given by a rather "free" service orchestration), such architecture may lack of inter-operability, mostly as far as industrial information systems are concerned. In this paper we propose an architecture to couple both management and production processes in a common service oriented approach so that different levels of inter-operability can be supported.

1 Introduction

Due to the economical context involving more and more customization and "service oriented products", enterprises have to adapt their organizational strategy: while focusing on their core business, outsourcing or collaborative strategies must be set to fit the market requirements (i.e. getting a critical size and being able to provide a high service level to the consumer). These organizational trends enhance the enterprise's agility, i.e. the ability to answer to structural changes quickly (client requests, technological or activity changes, supplier management…) [4, 7] and to reduce waste (leading to lean manufacturing organization) [12]. These organizations make a heavy use of information and communication technologies leading to increase the call for IT inter-operability: their performance level is related to an efficient information sharing system so that deviation risks are reduced [2]. Moreover, the efficiency involves also to take into account lean manufacturing [9] constraints while organizing the enterprise so that service and the associated processes should be strongly coupled. **Consequently, this context requires both an**

agile Information System and an agile organization to allow « on-demand » re-configuration.

While traditional information systems focus on the management and business sides, a particular attention must be paid on the production (or industrial) side to support efficiently co-production constraints. This leads to take into account several inter-operability constraints:

- "Organizational" inter-operability means that enterprises must share a same goal and have compatible management strategies
- "Industrial" inter-operability means that enterprises must share information on production processes and on product information
- "Technical" inter-operability means that the different components of the information systems can share and exchange pieces of information
- Semantic inter-operability means that the different systems can understand in a similar way a same piece of information.

After introducing the context, we'll focus on the architecture we propose to integrate "workshop information systems" into the enterprise global information system.

2 Context

Due to the high diversity of the IT support systems according to both a technological point of view (several languages, DBMS, information internal organisation…) and to the supported functions (ERP are devoted to management and planning functions while PLM manages technical data and MES are in charge of production monitoring… [10]) the enterprise information system is complex. To bring more flexibility, the Service Oriented Architecture paradigm consists in orchestrating conveniently "services", i.e. components. Based on a common referential, such an architecture is used to interconnect the different IS components, i.e. ERP, CRM, SCM… systems. Thanks to a service repository service consumers can locate dynamically the service they need before executing it remotely thanks to a service request/ service result mechanism (using the SOAP protocol). Despite of its intrinsic openness, this orchestration mechanism leads to a formal workflow structure of the business and management processes.

Workflow based approaches can be fruitfully used to support both business processes and production processes description [5] but these "on demand" made tools may increase the information system complexity and inconsistency. ICT tools supporting the production process execution (as MES, Profinet CBA…) are based both on web technologies (including web services) and a workflow based model to support the production process description [10]. Consequently, as they are supported by similar technologies, both service and production views can be coupled at a technological level. This involves adding new connections to the enterprise information system as shown figure 2 to set an industrial information system. Moreover, integrating the production process in the common orchestration involves also managing its maturity level to identify the exact process organization to use (ad-

hoc or formal workflow) and its impact on the workshop management system. This involves a full re-design of the SOA orchestration principle.

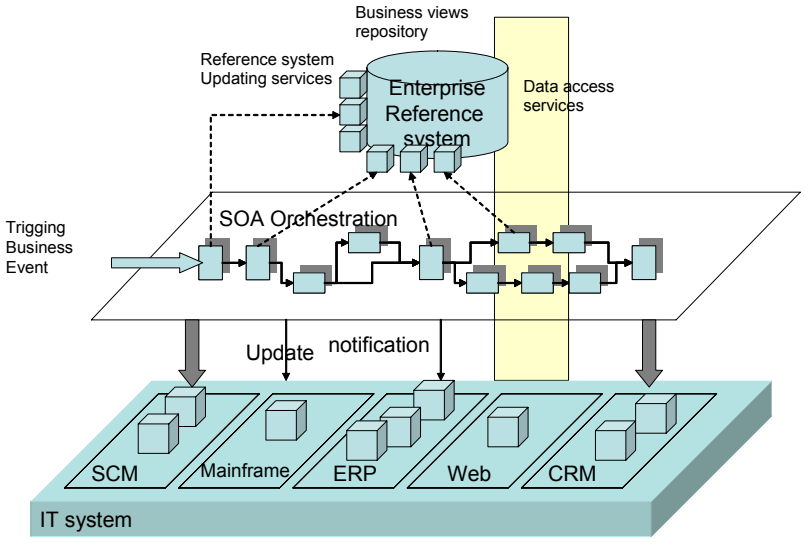

Fig. 1. Using the SOA paradigm to federate the enterprise information system

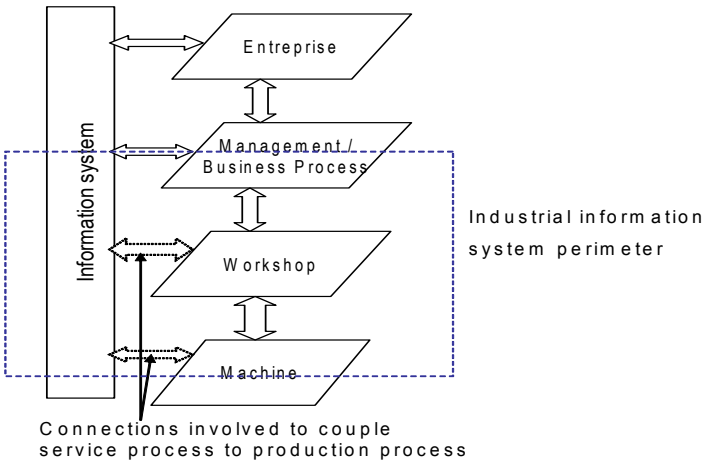

Fig. 2. Industrial information system

Nevertheless, using the SOA paradigm is not enough to bring the required agility level to the IS. As the global IS is a complex system, one must re-organize it in order to get a simplified structure, easier to manipulate and to control evolutions. To solve these problems, the information system urbanization approach [8] splits the information system into sub-systems related to different business areas [1]. Coupled

to a Service Oriented Architecture (SOA) this urbanism approach also splits the information system into different levels, separating activities from the information system and from the technical infrastructure. Thus, the introduction of the Service Oriented Architecture (SOA) enables to design flexible and reactive environments federated by an applicative "bus" orchestrating processes [3]. Using jointly the information system urbanism paradigm and a SOA information system organization improve the information system consistency (avoiding redundancy) and agility (ability to create new applications or services quickly with improved integration abilities as far as the impact on the information system is strongly localised). Nevertheless, as far as they are based on "top-down" logic to define processes [6], they do not overcome the intrinsic process rigidity. Moreover, these approaches **set an information and production system oriented on activities, according to the enterprise functional organizational chart, without taking into account the production process logic.**

3 Orchestrating an industrial information system

Designing a lean industrial IS involves taking into account both interoperability and "industrial orchestration" constraints.

First, to overcome the inter-operability limit, we propose to add an "inter-operable" organization constraint so that both service and production processes can be strongly related while designing the industrial information system. This inter-operable enterprise organization constraint leads to split the enterprise organization into several areas related to the production organization (so that evolution abilities are improved and processes can be designed incrementally). In this approach, "business areas" are related to the production organization and they integrate industrial flows, competencies, decisions and information viewpoints (figure 3). By this way, the full process (from the customer relationship management to the production and purchase activities) is organized in an autonomous way, using "services" provided by the different business areas. Consequently, it can be easily integrated in strong collaborative organizations and a high organizational inter-operability level can be reached. Implementing such architecture involves re-defining the process orchestration process to be able to re-configure process according to these organizational constraints.

This first constraint leads us to re-define the orchestration process: after searching the convenient services associated to the core process, extra services associated to the collaboration and security patterns are also retrieved and inserted while re-orchestrating the full process. Lastly, to take into account technical inter-operability, we propose to integrate standard to manage information exchange: dedicated services are used to format information into XML or B2MML formats. By this way a rather open and agile architecture can be built.

Then taking into account industrial constraints involves adapting the orchestration constraints to take into account the physical process own constraints:

1. Depending on the product, different maturity levels must be taken into account: from a basic production order leading to a rather informal

production process specification, well defined, automated and optimised processes can also be modelled into a formal workflow
2. Physical constraints (QoS, job duration, material flows) must also be taken into account while combining the convenient services set
3. Different points of view must be integrated while managing a workshop: concurrent workflow used to support production or resources management are simultaneously under execution. This involves orchestrating and scheduling conveniently services to be executed on a same resource.

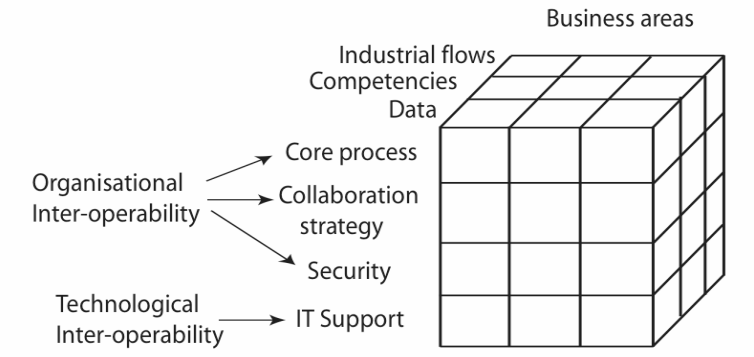

Fig. 3. Different inter-operability levels

To satisfy these requirements, we propose to split the process organisation into 2 parts. The "core" production process (called "process" in figure 4) provides a generic model including both the routing and the bills of material. This common interface is used to generate local implementation, taking into account the exact manufacturing process. The industrial interface, set between the Business/Production abstraction level and the Technical Abstraction level consists in:

1. The industrial flow interface: this area is devoted to exchange information taken from the routing and from the bill of material to define the different resources involved in the manufacturing process
2. The process maturity level: this area is used to set the process maturity level defined according to the CMMI discrete scale [11] (see figure 5): the initial level is devoted to basic production order with an informal description and is associated to a simple ad-hoc workflow. Then, level 2 is used when the manufacturing workflow can be defined formally. Level 3 and higher impacts the workshop manger so that generic models, performance indicators and dynamic tuning can be achieved.
3. Manufacturing constraints as QoS requirements, synchronisation points… are described so that the orchestration can be efficiently monitored to fulfil these requirements.

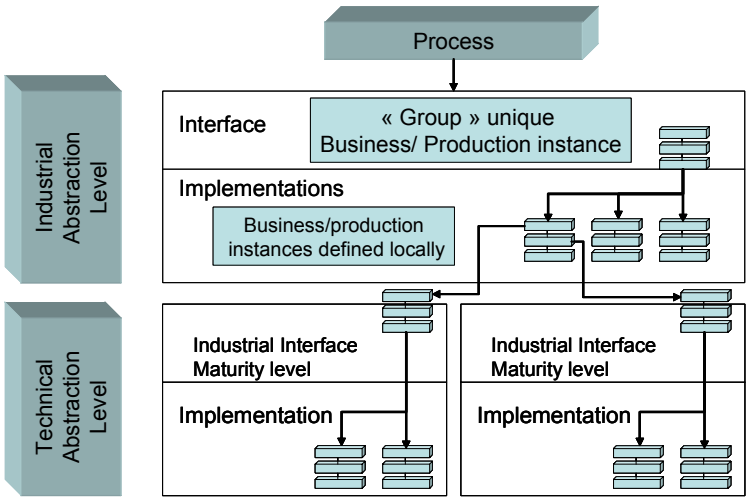

Fig. 4. Process organisation

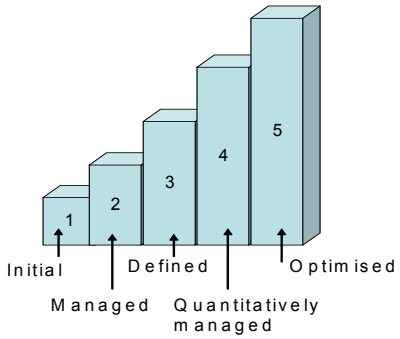

Fig. 5. CMMI discret escale

- Level 1: Initial : ad-hoc and chaotic process. Non stable manufacturing environment
- Level 2: Managed: processes are more formalised so that they can be
- Planned, performed, measured and controlled
- Level 3: Defined: processes are well characterized and understood and are described in standards, procedures, tools and methods
- Level 4: Quantitatively managed: performance indicators and dashboards are attached to the process
- Level 5: Optimising: process are continuously improved.

In order to manage both the manufacturing process and the workshop, we split the industrial orchestrator into 2 parts:

- The manufacturing orchestrator is devoted to the manufacturing process enactment and supervision (taking into account both ad-hoc and formal workflow)
- The workshop orchestrator is split among the different resources and integrates the workshop management workflow.

Building such an architecture involves organising a distributed workflow management. A continuous tuning is achieved, integrating the manufacturing industrial constraints to schedule conveniently the different tasks on the resources. Moreover, the workshop orchestrator is also used to optimise globally the workshop and consequently to orchestrate the physical flows between the resources.

4 Conclusion and further works

In this paper we present how the service oriented architecture can be used to support an agile industrial information system. Firstly set for traditional information systems, we enrich this approach to integrate inter-operability and manufacturing constraints in the orchestration process. Nevertheless, a simple "manufacturing orchestration" is not enough to manage conveniently the production processes. Taking into account the manufacturing maturity level (adapted from the CMMI discrete scale) allows the orchestrator to select the convenient workflow management systems (ad-hoc or formal workflow, connection to the workshop management process…).

Further works will focus on the different workflow integration so that a global optimization could be achieved while "orchestrating" a resource activity.

Acknowledgements

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