

Supporting the entire life-cycle of the extended manufacturing enterprise



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ABSTRACT

This paper presents a framework to support the full life-cycle of extended manufacturing enterprises, from creation to operation and dissolution phases. The deployment and operation of such enterprises can be compared with the concept of 'plug-and-play', as the internal processes and legacy systems of the companies involved are smoothly integrated within an overall business process designed, validated and executed according to a specific business opportunity. During the plug phase, the specific business requirements are elicited and integrated with the design of the extended business processes. On the other hand, in the play phase, those predefined processes are executed in order to run the extended enterprise successfully. The paper describes an application case regarding an engineer-to-order and one-of-a-kind engineering product. This scenario is common to a large number of technology-driven SMEs, and illustrates the value of the framework to exploit business opportunities that require a combination of skills and resources that do not exist in-house. The case shows how the platform addresses the two main challenges in the deployment of an extended enterprise. The first challenge is finding the right set of partners to address a new business opportunity and the design of the underlying collaborative processes. The second challenge is mostly technical, and focuses on the integration of the legacy systems of the partners participating in the network so that cooperation can take place quickly and seamlessly.

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1. Introduction

Nowadays, enterprises seek to adopt new business models and to explore new organisational models, such as dynamic networks and virtual enterprises, to quickly respond to market opportunities while assuring fast time to market, a differentiated offer and competitive prices [1]. Furthermore, business-manufacturing sustainability will focus more and more on high-variety, low-volume and quick delivery businesses models associated with complex products [2] which require a combination of multiple skills that, in an SME, may not exist in-house. Over the last decade, several research initiatives and projects tried to address the needs and requirements of such emerging business models. However, in spite of this effort, currently there are no proven or effective methodologies, approaches or tools to support the enterprises in creating, managing and participating in the collaborative networks inherent to this type of business models (e.g. dynamic networks and virtual enterprises) [3,4].

Collaborative networks in industry come in a large variety of forms. Moving from the classical supply chains format, characterised by relatively stable networks with well-defined roles and requiring only minimal coordination and information exchange, more dynamic structures are emerging in industry. Some of these organisational forms are goal-oriented, that is, focused on a single project or business opportunity, such as the case of virtual enterprises [5].

Manufacturing networks and "Virtual Enterprises" have been widely discussed over the past decade [15,16]. In this research, the definition of virtual enterprise considered is based on the definition proposed by Camarinha-Matos [5], which states: a Virtual Enterprise represents a temporary alliance of enterprises that come together to share skills or core competences and resources in order to better respond to business opportunities, and whose cooperation is supported by computer networks. A "Virtual Manufacturing Enterprise" is one form of Collaborative Networked Organisations [6] that allows partners to exploit emerging business opportunities in a flexible way. An "Extended Enterprise" is viewed as a particular case of a virtual enterprise. It occurs when an organisation "extends" its boundaries to all or some of its suppliers, which is the case of several innovative SMEs in the manufacturing industry.

In the context of these research topics [6], several categories of

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goal-oriented collaborative networks have been identified and defined, and four of them are grasping opportunity-driven and naturally relevant in the scope of this research targeting the collaborative manufacturing domain [4]. These grasping opportunity-driven Collaborative Networked Organisations are formed to meet a specific business opportunity, and will dissolve once their mission is accomplished. The concept of Extended Enterprise is also relevant for this research.

The effective implementation of a virtual organisation raises several challenges: the integration of human and technical resources to enhance workforce performance and satisfaction; the need to instantaneously transform information gathered from a vast array of sources into useful knowledge for making effective decisions; the ability to reconfigure manufacturing enterprises rapidly in response to changing needs and opportunities; and developing innovative manufacturing processes and products with a focus on decreasing dimensional scale.

Those challenges may be grouped in two main issues. The first is a business-oriented challenge where the goal is to find the right set of partners to address a new business opportunity and the deployment of the collaborative processes. The second is a mostly technical challenge, and the goal is to integrate the legacy information systems of the partners involved in the collaborative network so that cooperation can take place quickly and seamlessly.

This paper presents a framework that addresses these two main issues. The business issues comprise a reference model with a catalogue of business processes and practical approaches. To enable the technical integration issues of the extended manufacturing enterprise, the framework provides a technical platform offering several tools and mechanisms to leverage the exchange of information between factories at a manufacturing process level. The practical application example provided in the final part of the paper addresses these two issues in order to make it easier to understand the applicability of the framework to develop collaborative business opportunities in an engineer-to-order and one-of-a-kind production SME.

2. The plug and play virtual factory concept

The concept of combining the power of several independent business entities to implement complex supply chain processes, such as the so-called virtual manufacturing enterprises, is not new

and has been addressed by several research projects in recent years [3,5,6,19]. However, most of them are limited to creating virtual manufacturing enterprises at business level, and in many cases they concentrate on the partner-finding and factory-building stages. To this date, no proven tools and technologies exist on the market to provide valuable end-to-end integrated Information and Communication Technology (ICT) in such environments [3]. Thus the current approaches do not allow for innovation and higher management and operational efficiency in networked operations and framework. The platform presented here aims to change this situation [4].

The framework introduced in the next section addresses the integration, interoperability, and collaboration challenges within supply chains, lowering market access barriers for SMEs, which usually neither have the capabilities to control the entire manufacturing life-cycle nor the market power to enforce their own interfaces and standards. This way, it will be easier for SMEs in the manufacturing industry to engage in collaboration networks in the context of virtual organisations.

Two different interoperability approaches were envisioned: one based on a hard integration between the partners' legacy systems and the management platform of the extended enterprise, and a soft integration approach allowing the participation in the extended enterprise through a cloud-based web interface. The first approach is suitable for larger companies with sophisticated management systems and capable of dealing with the technical integration of IT systems. The cloud-based approach may be more interesting to small companies with limited resources

The platform is based on the paradigm of Service-oriented Architectures (SOA), exploiting latest technologies from the "internet of things", and leveraging recent developments in the area of cloud computing. This way, the platform facilitates the participation of SMEs in large ad-hoc supplier/customer networks, providing the tools and methods to tackle the challenges described above and improving information exchange and sharing with the other partners of the virtual manufacturing enterprise [4]. The platform provides tools and methods to design, simulate, optimise, execute, adapt and monitor dynamic manufacturing processes through a web-based dashboard (see Fig. 1). The SOA manufacturing approach leads to the description of each virtual enterprise process step as a service [7,8] and allows manufacturing companies to model and manage their processes as a composition of distributed and heterogeneous services.

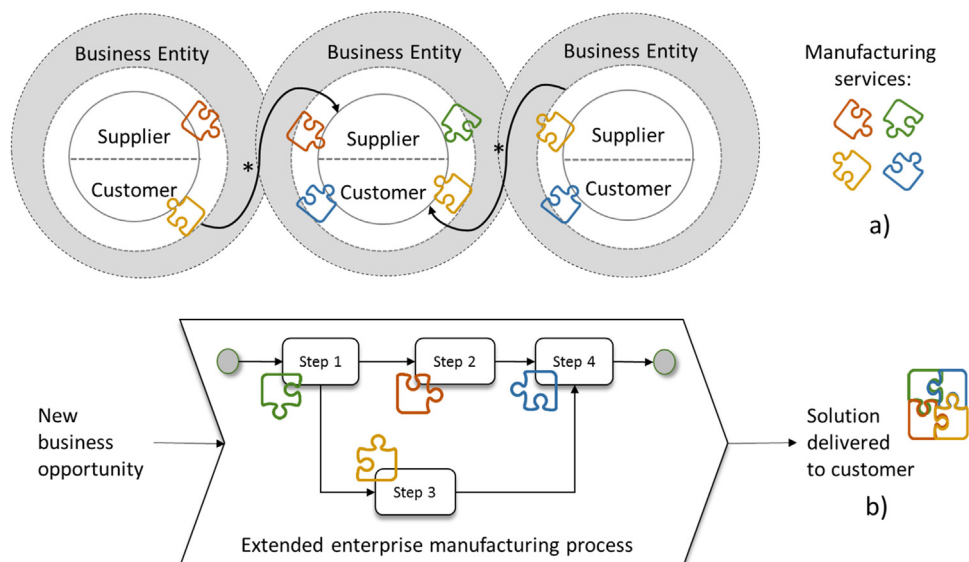


Fig. 1. The plug-and-play manufacturing concept.

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