



Architectures, methods and tools for enterprise engineering

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Abstract

In today's highly competitive global economy, the demand for high-quality products manufactured at low costs with shorter cycle times has forced a number of manufacturing industries to consider various new product design, manufacturing, and management strategies. Recently, due to the rapid advances in Information Technology (IT), new paradigms have successively emerged such as CIM, JIT, lean manufacturing, concurrent engineering, business process engineering and more enterprise engineering (EE). Enterprise modeling is currently in use either as a technique to represent and understand the structure and behavior of the enterprise, or as a technique to analyze business processes, and in many cases as support technique for business process reengineering. However, architectures and methods for EE have also to cover the integration of quality, information system, cost, human and organizational aspects and have to support the EE process from goal and requirements definition up to implementation and operation (Vernadat, 1999. Proceedings of CARS&FOF 99 Conference, Aquas de Lindoia, Brazil).

This paper provides an overview of architectures, methods and tools for EE. It then points out substantial results achieved so far as well as presents a methodology and a related tool in more detail, which supports all phases and aspects of EE.

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1. Motivation and requirements

The current economic disorder on the international scene is forcing enterprises to lean their manufacturing and management operations to be

more productive and efficient. This implies business process simplification and even outsourcing (be they administrative, management, design, manufacturing, or support processes) (Hammer and Champy, 1993). Modeling should emphasize the principle of separation of enterprise behavior (process model) from enterprise functionality (activity model) as well as separation from processes to resources to achieve organizational flexibility.

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Qualitative and quantitative properties of business processes must be analyzed. Another important aspect of process behavior analysis is the evaluation of process performance. Also, plant layout design and logistic systems of the operative part of the enterprise must be analyzed and optimized. Last but not least, the quality management system has to be built up and certified according to ISO Standards (ISO 9000 ff. and QS 9000 ff.).

The complexity of new products calls for a better management of complex business processes in many projects of collaborative nature. Hence, integration problems arise from different perspectives (Vernadat, 1999):

- *Integration of markets:* New free trade economic zones are being established around the world (e.g. the European Union, the North American Free Trade Act, Mercosur in South America, or the Indonesian market) forcing companies to adapt to regional product consumption and servicing customs.
- *Integration between several development and manufacturing sites:* Integration of markets will favor collaborative ventures between remote enterprises contributing to complex products (e.g. AIRBUS airplanes). This has consequences on exchange of technical and production data (information flow), project management (control flow) as well as on distribution and logistics (material flow).
- *Integration between suppliers and manufacturers:* To reduce product lead-times and share the risks in launching new products, manufacturers and suppliers must integrate and synchronize their processes.
- *Integration of design and manufacturing:* To reduce the time-to-market and minimize design errors, concurrent engineering practices must be deployed enforcing the need for more integration of design and manufacturing activities and knowledge.
- *Integration of multi-vendor hardware and software components:* Open systems architectures are needed to provide interoperability of various IT hardware and software solutions commonly used in industry environments.

Essential conditions for integration seem to rely on the free but controlled flow of information and knowledge, and the coordination of actions. Integration is a way of breaking down organizational barriers which have resulted from the traditional hierarchical management principles (Vernadat, 1999).

Another important way to reduce and handle complexity of management of business processes is the reusability and adaption of existing structures. According to Enterprise Modeling, existing pre-defined models from 'best practice' could be reused and then adapted to the specific constraints and conditions of a specific company. According to Enterprise Engineering, the information captured in the analysis phase must be reusable and adaptable in later phases of design and implementation of new structures and processes within an enterprise. That means models are 'reference guides' and 'documentation facilities' through the whole Enterprise Engineering process.

Things to be modeled and integrated include (Vernadat, 1999):

- *Orders:* An industrial system is driven by customer orders from outside, which are then divided into different kinds of internal orders (procurement orders, production orders, design orders, etc.).
- *Products:* They are described by means of two things: a *product model* containing all technical data about products, and a *design process model* defining the business processes describing how the products have been designed.
- *Business processes:* Processes use, process, or produce materials, data, information, or knowledge. Most of these concurrent processes also need to be integrated so that they can be executed cooperatively and in a cost-effective way to perform necessary enterprise operations.
- *Technical resources:* An industrial system is made of a number of physical machines and devices as well as technical agents such as computing systems (e.g. computers, database servers, etc.) and application systems (i.e. software packages).
- *Information resources:* Data and information systems as well as information flows.

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