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Using Systems of Systems Engineering to Improve the Integration of Enterprise-Control Systems

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As the lifetime of many products (that is, goods or services) gets shorter, enterprises have to evolve their information system to account for changes in the internal and external business environment. Indeed, enterprises are using more and more software applications, such as APS, ERP, MES, and SCM,[1] to deal with the increasing complexity of information flows. Moreover, these applications are often distributed among facilities with various owners and many suppliers (see figure 1). However, this supply-chain environment is quite unstable, because consumers/customers have an increasing need to customize their products in ways that respond to the changes in supplier networks. That has come about as a result of the new phenomenon of extended enterprises. These business constraints cause issues with short-lived relationships about the way the systems interoperate. In a more general way, this happens not only to enterprise software applications but also to any enterprise system that handles information.

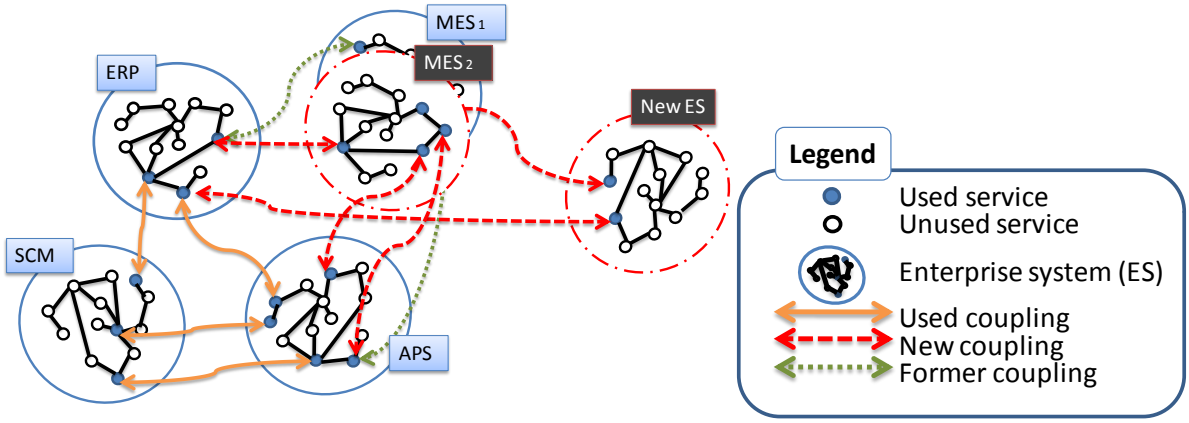

Figure 1. The complexity of enterprise systems' interoperability

The Research Centre for Automatic Control, Nancy, France, has been studying these interoperability issues for several years. The research team focused on product-driven systems control has suggested a new paradigm: "product-driven interoperability."(Morel, Panetto, Zaremba, and Mayer 2003). In particular, in his PhD thesis, Jean-Philippe Auzelle is studying interoperability issues and formalization, where enterprise systems are dealing with information management in a manufacturing context.

In this context, a product embedding information about itself and being able to communicate with its environment may be qualified as an "active product." Among other information, such a product defines the set of capabilities needed to produce it. In order to be manufactured, those defined capabilities are provided by resources within a manufacturing system. These resources are controlled by a set of enterprise systems. When an "active product" joins this set of enterprise systems (figure 2), we are demonstrating that the new system (existing enterprise system as well as the product) is characterised by some specific properties derived from autonomy, belonging, connectivity, diversity, or emergence. From this new system emerges a new mission devoted to

[1]. These are the advanced planning and scheduling system, the enterprise resource planning system, the manufacturing enterprise system, and the supply chain management system.

processing this new coming "active product" (Morel, Panetto, Mayer, and Auzelle 2007). This new system may then be assimilated to a system-of-systems (Boardman and Sauser 2006) by gathering all enterprise systems, considered themselves as autonomous systems, together with the active product. All enterprise systems are also connected to the active product through an interoperating relationship that must be formalised. Intuitively, we were then inspired by the system-of-systems paradigm and all associated tools and models to study a system-of-systems-like perspective for integrating enterprise-control system.

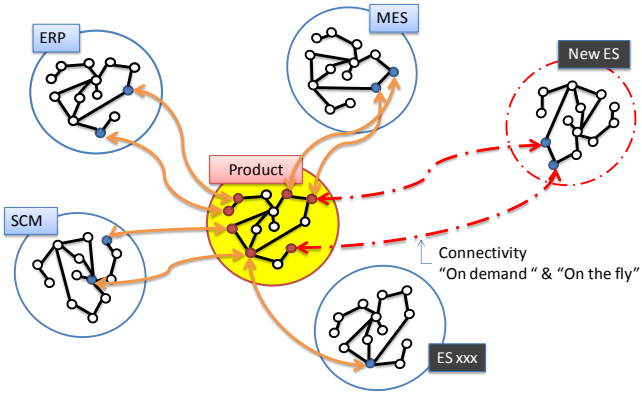

Figure 2. Product-driven interoperability

In this system-of-systems-like context, our current research addresses the formal mathematical definition of a product-driven interoperability relationship, taking into account a short-lived connectivity between an active product and a set of enterprise systems. This relationship implies "on the fly" information exchange for ensuring "on demand" processes.

At present, technologies based on enterprise application integration (EAI) or service-oriented architecture (SOA) offer languages and protocols to aid exchange of service-based information. Semantic requirements are not taken into account with these tools. Consequently, our research challenge is to explore the perspective of semantic relationships to give it more transparency and make interoperability seamless.

Our ongoing work aims to explore systems engineering processes and standards, such as STEP (*ISO 10303:233*), thus proposing a methodology to consider the formal semantics relationships between the involved enterprise system and the so-called active product. This new approach will open new avenues to manage the manufacturing process, considering each active product as a system per se that may interoperate with each enterprise system, enhancing then new planning perspectives in the manufacturing world.

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Acronyms: APS (Advanced Planning and Scheduling system) ; ERP (Enterprise Resource Planning system) ; MES (Manufacturing Enterprise System) ; SCM (Supply Chain Management system) ; EAI (Enterprise Application Integration) ; SOA (Service Oriented Architecture) ; STEP (STandard for the Exchange of Product)