Dissertation title:

Adaptive and changeable IT-Architecture for manufacturing companies

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The challenges manufacturing companies are confronted with nowadays are increasing steadily. They include growing globalization, increasing complexity and prevailing turbulent environments [Jovane 2009]. Due to globalization, every company has to face up to the competition as well as a diversity of markets in a distributed environment. The increasing complexity is not only caused by the rising number of product variants, but is also rising equally on the process level. The problems are amplified even more by the turbulent environment, which is characterized by internal and external influences, e. g. machine failures, order fluctuations, or changing legal regulations. Manufacturing companies thus need to continuously adapt to the current situation [Westkaemper 2007].

In order to support employees and to make administration more efficient, more and more information technology (IT) is introduced in manufacturing companies. The multitude of software systems and their usually proprietary integration are quickly resulting in complex IT landscapes, which continuously increases the maintenance effort. Additionally, the software applications as well as their integration are inflexible [Kirchner 2003], therefore, changes and extensions can only be conducted with great effort. The processes implemented in the applications are inflexible as well, which is why changes that are necessary due to frequently changing requirements cannot be performed as fast as needed. Furthermore, integration solutions are typically limited to a single domain and do not provide enterprise-wide data exchange or cross-domain process definitions.

Because of the above-mentioned reasons, a new IT architecture, which supports the integration of applications and processes in an adaptable way, is necessary. This thesis describes such an adaptable and changeable IT architecture (ACITA) for manufacturing companies [Silcher 2011]. Its initial application domain is the product life cycle, or Product Lifecycle Management (PLM), though it can easily be extended to support other domains. The integration of software applications is based on uniform service interfaces, which are implemented in the standardized web service technology. The loose coupling of services is enabled by an adapted Enterprise Service Bus (ESB). Processes are supported by a flexible composition of services into workflows that execute business services or business processes. Each domain is integrated separately by using such a phase-specific ESB. This way, the technical requirements of each phase, e. g., data throughput, data structure, and latency each ESB has to process, can be taken into account. Consequently, the resulting IT landscape is more efficient. The integration of the single domain-specific ESBs is accomplished with a further ESB, the so-called PLM-Bus. This PLM-Bus provides a changeable IT architecture by enabling the simple addition of phase-specific ESBs.

The implementation of the ACITA requires a set of several components. To access the functionality and data of the applications that are to be integrated, service interfaces are needed. The management of these service interfaces, or services, is accomplished by multiple service registries that follow the hierarchy of the ACITA [Silcher 2013a]. Within each domain, a local service registry manages and stores the service information of the corresponding phase. The PLM-Bus uses a meta service registry to provide service information for cross-phase message exchange. This meta service registry only stores the relevant service information needed for service endpoint retrieval in remote phases. Confidentiality can therefore be guaranteed, e. g., concerning the integration of external services of partners.

The content-based router (CBR) dynamically determines the destinations of each message by using rules. Subsequently, the service information is retrieved from the corresponding local service registries for each destination service. Each phase-specific ESB is therefore associated with a CBR and with a local service registry. The CBR forwards all messages to the locally available applications or to the CBR of the PLM-Bus. This global CBR then sends the messages to the appropriate CBR of the destination phases where the message is finally delivered. Altogether, this leads to a loose coupling of services within the whole ACITA.

The dependencies between applications and their proprietary data formats can be decoupled by introducing common message exchange formats. Each phase is integrated separately by using its own common data format, which only contain data exchanged within the corresponding phase. For cross-domain message exchange, an additional global message format, which only contains data exchanges between the integrated phases, is defined. Compared to a single message format, this separation of common message exchange formats reduces the complexity for the whole ACITA, leading to a reduced effort for maintenance and extensions.

Different common message formats require translation services for cross-domain message exchange. Therefore, each message is transformed from the local message format into the global message format and afterwards into the local message format of the destination phase.

The ACITA is initially intended to integrate the heterogeneous phases of the product life cycle in a homogeneous manner. Moreover, the high modularity of this architecture allows for an easy extension to integrate other domains within a production company or even external services of partners. Such a phase model is described in the holistic management model, which, aside from the product life cycle, also integrates the factory life cycle and the supply chain [Silcher 2013b]. This holistic integration approach enables an improved data and information exchange as well as a continuous process support between cooperation parties.

The prototypical implementation of the ACITA was conducted in the learning factory aIE, which contains a digital learning shell and a physical model factory [Riffelmacher 2007]. The PLM-Bus integrates the domain-specific integration platforms Productionplanning Service Bus (PPSB) and Manufacturing Service Bus (MSB) to demonstrate the seamless and flexible data exchange between the corresponding phases [Silcher 2013a].

Four usage scenarios accompany the evaluation of the ACITA and show the benefits of an improved adaptivity and changeability of this integration architecture as well as the higher flexibility of process support. Subsequently, a comparison of the ACITA with other integration approaches in research as well as with commercial software is presented. In comparison to the commercial software, the ACITA allows for a higher flexibility in integration and process support. Integration platforms such as the Engineering Service Bus (EngBus) [Katzenbach 2011] or Manufacturing Service Bus (MSB) [Minguez 2012] are mainly restricted to a single domain and do not provide a cross-domain integration such as the one enabled by the modularity of the ACITA.

In conclusion, the ACITA can provide a vital integration of distributed applications and services of all local sites of a globally acting company. The consistent use of software systems combined with flexible process support makes the growing complexity of products and processes more managable. The necessity to continuously adapt to new situations caused by the turbulent environment can be fulfilled easier through the adaptivity and changeability of the IT architecture. As a result of this, manufacturing companies are well-prepared for challenges in the future.