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Enterprise architectures for the digital transformation in small and medium-sized enterprises

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Abstract

The transformation towards smart connected factories causes enormous changes in mechanical engineering industry starting from the development of cyber-physical production systems up to their application in production. Enterprise architectures already offer suitable methods to support the alignment of the internal IT landscape. New demands like customer involvement, iterative development and increased business-orientation arising with these digitized products require new approaches and methods. This paper presents the foundation and the first steps aiming at the development of a method for the holistic planning of the digital transformation in small and medium-sized mechanical engineering enterprises.

1. Introduction

Currently, customers increasingly strive for maximization of personalized value. This becomes particularly obvious in the demand for individualized products and the increasing influence of customers on the development and the production processes [1]. Factories can only meet this challenge by the application of digital technologies. In Germany, the term Industrie 4.0 represents the aspired target state. Through improvements in information, communication and automation technology live information is available over life cycles of products, processes and factories. Production systems, products and humans are closely networked. Moreover, the resulting big data is used for holistic optimization. [2, 3, 4] This special situation gives rise to opportunities and risks for mechanical engineering enterprises. Based on customer data there are numerous new possibilities for product and process improvements including the optimization of the machining process or spare part forecasting services. At the same time, they are confronted with new demands. Customers not just want to buy a physical machine but service systems, consisting of hard- and software, that offer additional value in their unique context [1, 4, 5]. Examples are context-based

features and information for machine operators that support manufacturing to adapt rapidly changing customer needs. To realize such use cases a close collaboration of manufacturers and mechanical engineering enterprise is required. Through this development, IT is not any longer just a technological tool to improve the efficiency of internal processes. By becoming an essential part of the value creation it grows up to a new source of competitive advantage and thus takes a transformative role [5]. The required extension of products by digital components to the point of cyber-physical systems and their integration into service systems leads enterprises in mechanical engineering into a fundamental change process – the digital transformation. Besides mechanics and electronics they now need to develop digital capabilities and implement them into fast-changing, cross-company processes and structures. Especially for small and medium-sized enterprises (SMEs) this is an enormous challenge [6].

With the help of business model appraoches, many enterprises already started to design digital value creation concepts. But these means are very limited when it comes to deriving and implementing processes and IT services. In contrast to existing IT-based products, the new service logic requires a holistic process view. To take full advantage of the

digital opportunities adequate models, methods and tools are needed [4, 7]. With enterprise architectures (EA) information systems literature already offers a well-proven solution for this challenge [8, 9]. The aim of this paper is to examine if this approach is appropriate for digital transformation in SMEs of mechanical engineering. Therefore, digital transformation and EA are defined. Afterwards, strengths and weaknesses of EA in the context of digital transformation in SMEs are analyzed. In addition, this paper presents the first steps for the development of a method for the holistic planning of the digital transformation in small and medium-sized mechanical engineering enterprises.

2. Digital Transformation in Small and Medium-sized Enterprises

The following section outlines the state of the art in the field of digital transformation in SMEs. First, a closer look at the definition of digital transformation is required. In change management, the term transformation is used to describe the extent of strategic change. Whereas in a realignment there is just a slight change in the way an enterprise operates, in a transformation it changes its paradigms of doing things. [10] As shown in figure 1 in enterprise transformation literature the term is defined as a fundamental change during which enterprises reinvent themselves. This contains a change of the context in which the enterprise is active. The context includes the way of operation and the previous sources of success. Moreover, the enterprise substantially alters its relationships with its key constituencies like customers, suppliers or employees. The initial point of transformation is a radical change in the economic or market context. This can lead either to an experienced or an expected value deficiency and thereby influence the speed of change. [11, 12] On this basis it can be distinguished between an evolutionary transformation in incremental steps and a revolutionary transformation by a big bang. The speed of change depends in most cases on whether the enterprise is forced to or changes proactively. [10] Result of a transformation is a conscious and sustainable change in business performance [11]. It may lead to new value propositions as products and services, different ways of interaction with the customer in terms of delivery and provision of offers and new organizational forms to provide these offers to the customer [12].
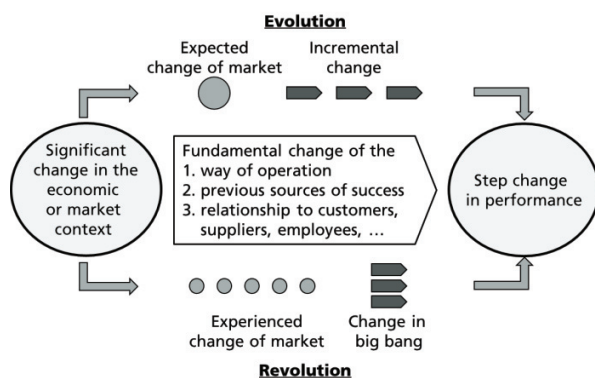

Fig. 1. Process of enterprise transformation.

The term digital covers gathering, storing, processing, providing and using information electronically with the help of information technology (IT). Through ever lower costs and the increasing pervasion of IT nowadays large information volumes can be shared worldwide at minimum costs. [3, 5, 13] The internet of things brings this development to the next level. By sensing and analyzing the context of the customer, this approach enable enterprises to get a deep insight into the customer motivations and create by this personalized customer value. [3, 5] One of the consequences is an enhancement of the relationship between provider and customer. Through the close networking of customers and providers digitization blurs the differences between them and enables cooperative value generation, also referred to as co-creation. Products evolve into services which are aiming at maximum value for both. [5, 14] Simultaneously digital technologies enable a fundamental reshaping of business towards cross-functional, modular and distributed processes [14]. This development increases business agility and empowers enterprises to act in turbulent environments like ecosystems. Ecosystems are self-containing and self-adjusting systems of loosely coupled actors that jointly create value. The basis of their relationship are institutional logics from which a set of rules and principles is derived. The importance of traditional, linear value chains decreases. [5, 15] A basic instrument to leverage the advantages of ecosystems are platforms. These modular structures facilitate the interaction between the actors. Platforms support the installation of rules for exchange and modular architectures. [5, 14] In summary, digital technologies become essential part of the value creation. For mechanical engineering enterprises as well as for new market actors this development offers chances to create new competitive advantages. Moreover digitization offers a possibility to fulfill the existing customer demands for a highly flexible supply of individual products. By reason of these significant changes the digitization can be seen as the initial point for a new wave of transformations.

At the moment, there is no common definition for the digital transformation. The following literature sources give a hint on the current discussion. Schallmo points out the networking of the value chain for improved decision-making. He defines digital transformation as the connection of actors over the value chain and the application of new technologies. In his view digital transformation demands capabilities for the gathering, the exchange, processing and analysis of data. The aim is to support decision processes and to initiate activities. Digital transformation influences enterprises, business models, processes, relationships and products to improve the performance and scale of the enterprise. [16] According to Matt et al. digital transformation involves the application of digital technologies with the aim of a change of key business operations, products, processes, organizational structures and management concepts. The authors describe manifold benefits like increased sales and productivity as well as innovations in value creation and customer interaction. [7] Nandico describes digital transformation as a change of an enterprise with the aim to provide new or enhanced products, services or both to the customer. A key enabler for this new offering or enhancement is the application of information technology. Thereby, enterprises try to create new business models, customer experience or operating models. [8] Whereas Matt et al. see the impact of digital transformation rather broad,