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# Competence-based Planning of Value Networks for Smart Services

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**Abstract:** Today's manufacturing industry is confronted with fundamental changes in value creation. The tension between the two megatrends of digitization and servitization leads to new hybrid market offerings, so-called smart services. Corresponding value networks fundamentally differ from traditional ones. Developing smart services requires new competences in young disciplines, while their provision requires new internal and external organizational structures or processes. To strengthen their competitive position, manufacturing companies need to adapt their value networks. However, the highly complex transformation of value creation especially challenges small and medium-sized companies due to limited competences and resources. They must consider opening their boundaries and collaborating with partners. In this paper, we introduce a basic framework for planning smart services and present a methodology for competence-based planning of value networks for smart services in three phases: Smart service analysis, competence analysis and value creation planning. The methodology is explained by an example from tooling machine industry.

**Keywords:** digitization, servitization, digital services, smart services, smart service planning, competences, value network, value creation planning, framework, methodology

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## 1 Transformation of Value Creation

For a long time the manufacturing industry was characterized by mass production, division of labour and rationalized value creation processes (Nickel, 2013). Manufacturing companies neglected direct contact with their customers. They mainly reacted by concentrating on the development, production and distribution of tangible goods (Aurich and Clement, 2010) or by diversifying their product portfolios (Wehner et al., 2016). Market offerings therefore include the sale of a wide range of products and complementary services such as product maintenance or product handling skills (Mittag et al., 2017).

Today's manufacturing industry is confronted with a fundamental change in value creation, with servitization being a main driver. Servitization is basically understood as adding value by supplementing products with services (Baines et al., 2009). It is highly attractive for companies, since the average margin profit typically increases with the share of services in market offerings (Münkhoff, 2013). In addition, the potential of services themselves lead producing companies to expand their service business along the servitization path (Figure 1). The transformation from producer to service provider with production requires a purposeful design in the three dimensions: behaviour, activity and structure. Adapting the behaviour of employees and managers, organizational restructuring as well as refocusing of activities within the company may be key success factors.

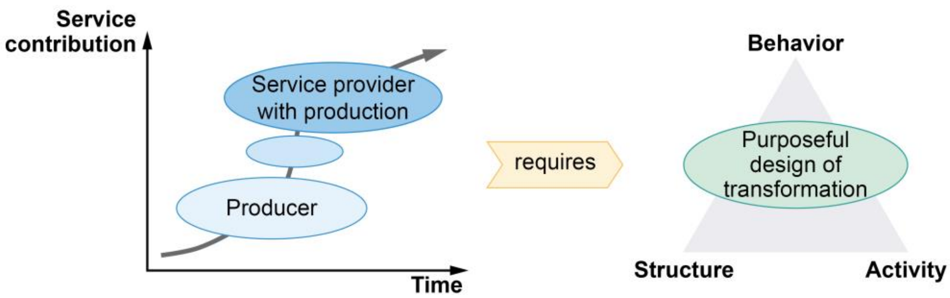


**Figure 1** Servitization path and its designing dimensions based on Schuh and colleagues (2004)

Another main driver for the fundamental change in value creation is the megatrend of digitization. Digitalization and its emergent technologies enable manufacturing companies to design, produce and offer their products in a new way (Linz et al., 2017). Rapidly evolving information and communication technologies are a prerequisite for vertical and horizontal integration. The use of intelligent products and production systems in the manufacturing industry enables innovative, cross-company value creation (Acatech, 2015). Physical and virtual value creation activities merge. Information, resources and objects are connected with each other and customers are actively involved in value (Porter and Heppelmann, 2015). The omnipresence of modern information and communication technologies permanently links value creation partners with each other and enables a multitude of new forms of collaboration. Figure 2 visualises the corresponding value creation structure in which an enterprise within a branch is connected with partners. These partners jointly create market offerings for the end customer via exchange relationships within a value network (Bach et al., 2012). Simple linear value chains are transformed into highly complex value networks of collaborating partners (Porter and Heppelmann, 2014).

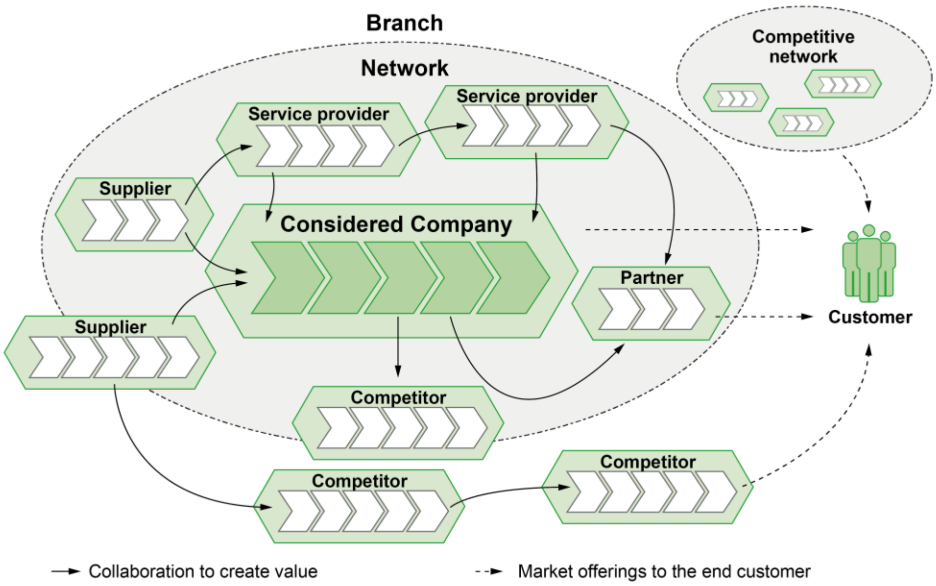


**Figure 2** Structure of value networks based on Bach and colleagues (2012)

The outlined effects of digitization illustrate that the anticipation of future value creation structures is of great strategic importance. An overview and a certain degree of control over the distribution of competences in value networks are essential for further entrepreneurial decisions, e.g. for setting up strategic partnerships.

## 2 Characteristics and definitions of Smart Services

The transformation of value creation outlined above is based on the field of tension between the two megatrends of digitization and servitization. Digitized products are a direct consequence of digitization. In addition to their physical, local functions, they generally provide globally usable digital functions (Anke and Krenge, 2016). These so-called cyber-physical systems (CPS) link the physical and digital worlds. As a result, the monitoring and controlling of physical processes is enabled through communication over digital networks (Broy, 2010). Following Mikusz's approach, CPS may also be understood as a product service system (Mikusz, 2014). Assuming the trend towards servitization, this opens a wide range of opportunities for innovation (Böhmann et al., 2014), especially in conjunction with digital services.

Digital Services that enhance a physical product building up on its data are called smart services. They differ from digital features in their ability to offer them with their own business model. Smart services may even be sold independently, provided the corresponding physical product has been delivered (Frank et al., 2018). The delivery of smart services requires an intelligently networked IT infrastructure. Another main characteristic of smart services is generating added value through continuous data collection and analysis (Paluch, 2017). Thus, they enable continuous communication and interactive feedback for customers and companies both. Smart services stand out from traditional maintenance and upgrades that are bundled with physical products. They create individual added value for the customer and increase cost efficiency for the company (Allmendinger and Lombreglia, 2005). Figure 3 shows a framework for smart services that considers the two dimensions of the kind of market offering and the dominant value creation. Smart services must consist of physical products and digital services. Frank and colleagues (2018) postulate that digital products and physical services may be optional components of a smart service. An example of a smart service that includes all four components is condition monitoring for tooling machines combined with automatically triggered repair service and software updates.

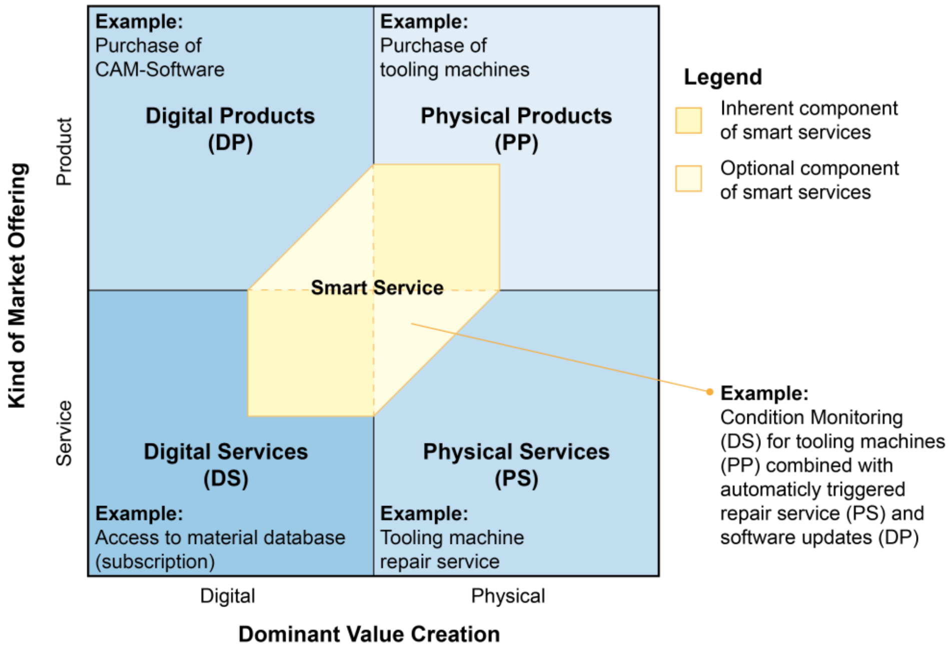


**Figure 3** Framework for smart services based on Frank and colleagues (2018)

In order to strengthen their competitive position, manufacturing companies need to adapt their value networks to provide smart services efficiently. However, the highly complex transformation of value creation raises major challenges. Especially small and medium-sized companies often lack sufficient competences and resources to implement smart services on their own. They must consider opening their boundaries and collaborating with partners to develop and provide smart services. However, as data-based smart services are integrated into a complex socio-technical system of stakeholders and technologies. Therefore, a multidimensional view considering business functions, technologies and human resources is indispensable (Drăgoicea et al., 2015), (Carrol, 2012), (Beaumont et al., 2014).

Koldewey and colleagues (2018) propose a framework that enhances the influencing variables on the value creation in the context of smart services shown in Figure 4. At the heart of this approach is the hybrid market offering, which comprises smart services and smart products. Key processes for generating value for the offering companies are the development, provision and billing. These processes are arranged in the following four value creation dimensions: human resources, organization, technology and business. This enables a comprehensive view of value creation in the context of Smart Services. The paper at hand focuses on human resources, particularly competences, and internal as well as inter-company organization. The other dimensions are considered implicitly.

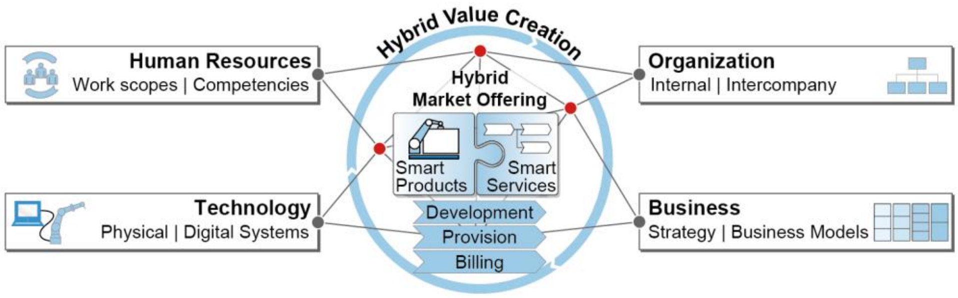


**Figure 4** Dimensions for value creation in the context of smart services (Koldewey, 2018)

## 3 Planning of Smart Services

Since smart services are integrated into sophisticated socio-technical systems and their development, provision and billing requires value networks that are highly complex, the requirements for planning smart services are correspondingly challenging. Frank and colleagues (2018) postulate particularly critical challenges regarding strategic planning, conception, scaling of smart services and the corresponding development of relevant competences. Mittag and colleagues (2017) point out that smart services have special impacts on the operational and organizational structure of a company as well as on its interactions with the environment. In order to meet these challenges and impacts, we propose a holistic framework for the planning of smart services that is shown in Figure 5.

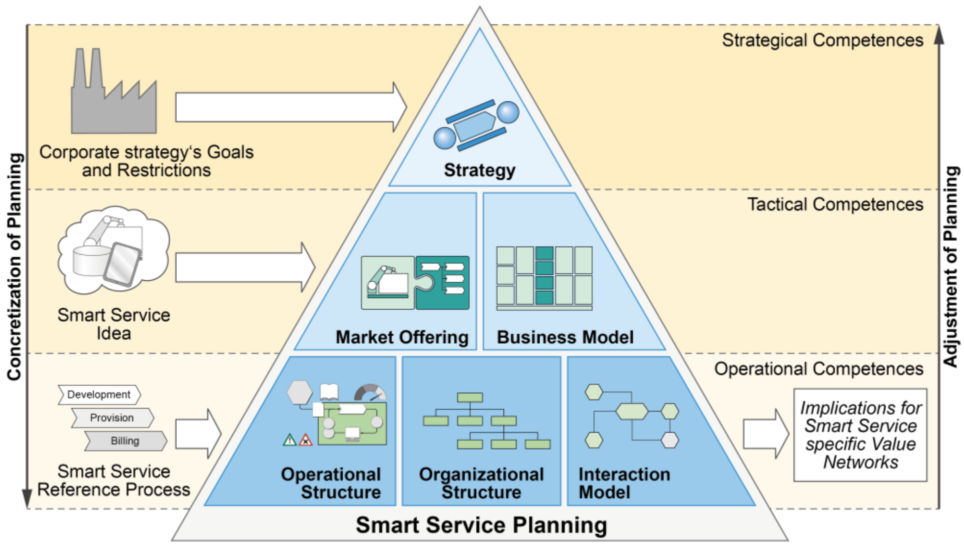


**Figure 5** Framework for the planning of smart services

Our framework for smart services planning consists of six elements that are assigned to three different competence levels. The strategic level is based on core competences, which define the strategic direction of thrust of a manufacturing company and provide a starting point for further strategy development. Therefore, corporate strategy’s goals and restrictions must be considered. Market offerings and business models are designed and defined on a tactical level. Against this background, tactical competences from specific domains such as industrial data analytics define success positions (Gausemeier and Plass, 2014). On operational level, the focus is on the organizational and operational structure of a company and its interactions. Operational competences are skills that are applied in a targeted manner using the necessary resources. Skills are characterized by the task to be performed and the discipline in which the task is performed (Rübbelke, 2016), (Schneider et al., 2018).

The present paper assumes strategy's goals and restrictions, a smart service idea to be specified and a fundamental smart service reference process as input values for the concretization of planning. Implications for smart service specific value networks to be derived on operational level are the basis for the adjustment of planning on higher levels.

## 4 Competence-based Planning of Value Networks for Smart Services

In this chapter, we first discuss the research approach on which the developed methodology is founded. Subsequently, the developed methodology is briefly presented with the help of its three-phase process model. A detailed description of each phase is then given using a consistent example from the machine tooling industry.

The methodology was developed at the University of Paderborn using the Design Research Methodology (DRM) introduced by Blessing and Chakrabarti (2009). They divide their DRM into four consecutive phases: 1) Clarifying of the research goal, 2) Conducting a first descriptive study (DS I), 3) Conducting a prescriptive study (PS) and 4) Conducting a second descriptive study (DS II). Clarifying of the research goal includes the definition of the goal itself, the specification of the theoretical foundation and the state of the art. By conducting the first descriptive study, a deeper understanding of the problem is gained and the requirements for the methodological support are derived theoretically and practically. The methodology itself is developed while conducting the prescriptive study and founds on experience and requirements from DS 1. The evaluation in practice is focused in the second descriptive study. Need for improvement is deduced by utilizing the methodology.

The research was conducted in the joint research project Instruments for pattern-based planning of hybrid value creation and work for the provision of smart services (IMPRESS). In addition to the University of Paderborn, 2 other research institutes and 7 mechanical and plant engineering companies are participating in the project. Furthermore, the method developed is based on the preliminary work of the project Instruments for the Performance Improvement of Enterprises by Industry 4.0 (INLUMIA).

The result of the research is a generic methodology for the competence-based planning of value networks for smart services. It consists of three phases: smart service analysis, competence analysis and value creation planning (Figure 6). The methodology is summarized shortly in the following and described in detail later on. For a better understanding, it is explained using an example from the tooling machine industry.

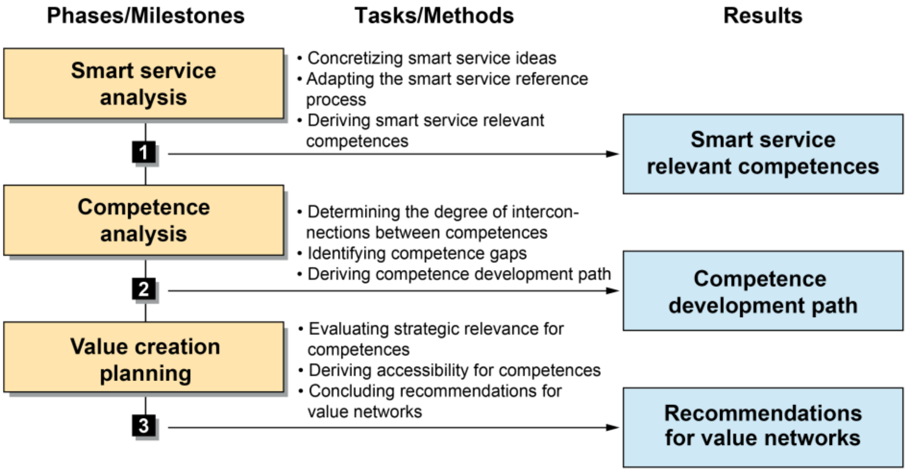


**Figure 6** Process model for the competence-based planning of value networks for smart services

In the first phase smart service ideas are concretized and their impact on value creation and operational competences is analyzed. The second phase includes the analysis of smart service relevant competences which are examined for their influence on each other. Additionally, a competence matching leads to a logical sequence for the development of smart service competences to be built up. In the last phase, these competences are evaluated from the company's point of view regarding their strategic relevance and reachability. Subsequently, statements can be derived about the allocation of competences in the specific value network for considered smart services. The result of the methodology are recommendations for the integrated and detailed planning of a value network for smart services and their implementation.

### *Smart Service Analysis*

The aim of this phase is to derive competences that are relevant to selected Smart Service ideas. In a first step, smart Service ideas are concretized with regard to strategical goals, possible applications, anticipated revenues and service processes. If the strategical goals that can be pursued with the Smart Service idea do not fit the existing corporate strategy, it is unlikely that the idea will be implemented. By anticipating possible applications and revenues, a ratio of effort and benefit can be derived as a basis for decision-making. Initial approaches to the actual service process allow conclusions to be drawn about concrete operational and organisational structures. Figure 7 shows an example of the concretized smart service idea *Wear detection for cold forming dies (No. 4)* that is documented in a profile.

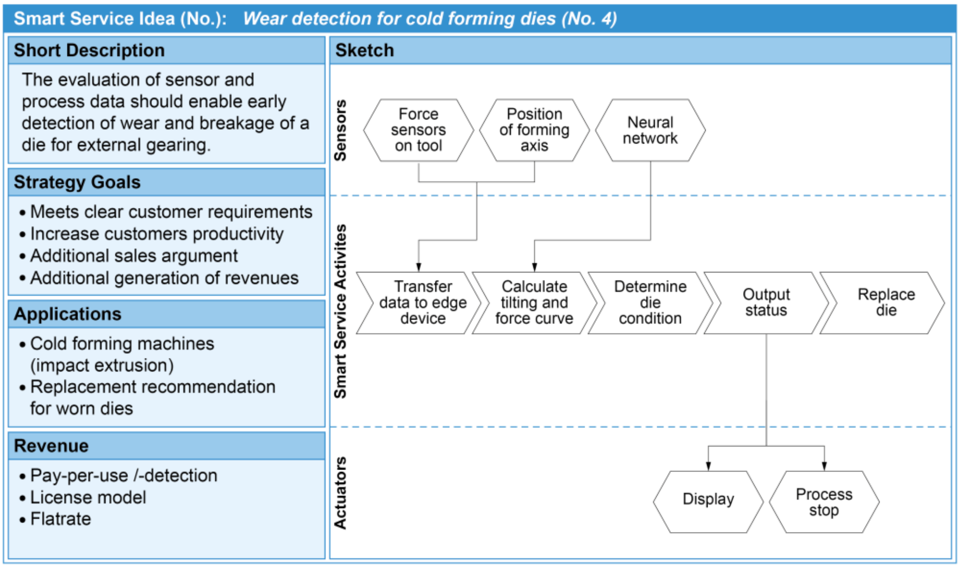


**Figure 7** Smart service idea profile for “Wear detection for cold forming dies”

In a second step, the smart service reference process is to be adapted and specified based on different information. On the one hand, the smart service profile already provides the idea in more detail. On the other hand, the operational and organisational structure of the considered company is to be included in the design of the smart service reference process as well. These are usually collected in workshops and interviews with experts. Subsequently, the phases of development, performance and billing are modelled using the OMEGA modelling language (Gausemeier and Plass, 2014). Figure 8 shows an excerpt of the smart service specific process organization for provision.

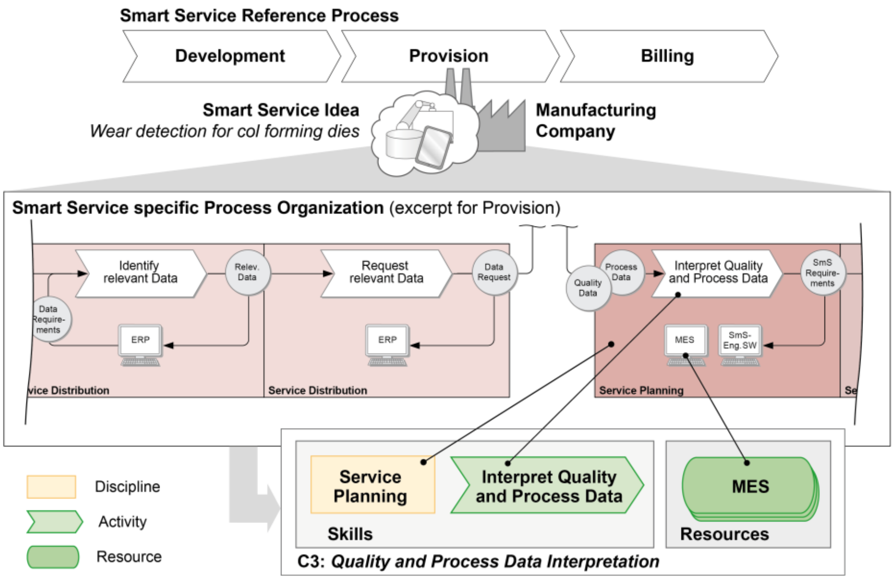


**Figure 8** Derivation of relevant competences for “Wear detection for cold forming dies” (excerpt for Provision)

The competences relevant for the smart service will then be derived with the understanding of competences according to Rübbelke (2016) and Schneider and colleagues (2017). For example, the competence *C3: Quality and Process Data Interpretation* is composed of the discipline *Service Planning*, the activity *Interpret Quality and Process Data* and several resources such as *MES*. In this way, each reference process phase is analysed step by step.

The result of this phase is a collection of smart service relevant competences. These will be examined in more detail in the following phases.

### *Competence Analysis*

The basis for the competence analysis phase are the smart service specific competences determined. These are examined for their influences among each other and subsequently transferred into a competence development path. The influence analysis determines the degree of interconnection of all relevant competences. Thus, the role of each individual competence in the complex impact structure of all competences can be determined. In addition to direct relationships, indirect influences over several competences are investigated as well. In this way, even complex relationships between the smart service-relevant competences are investigated and the degree of interconnection of individual competences more precisely determined. The influence analysis results in an active-passive-grid that is shown in Figure 9 as an excerpt for the provision of wear detection for cold forming dies.

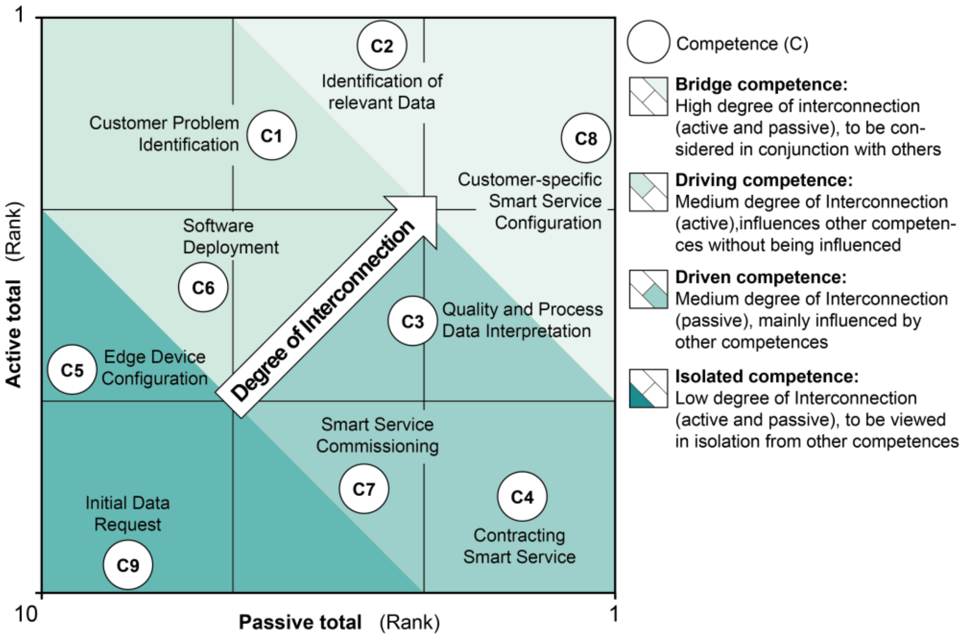


**Figure 9** Active-Passive-Grid for “Wear detection for cold forming dies” (excerpt for provision) according to (Rübbelke, 2016)

The Active Passive Grid comprises two dimensions: Active total and passive total. The active total indicates how strongly one competence affects the other competences. The passive total shows how strongly one competence is influenced by others. In order to derive initial recommendations for action for competence development, a further specification of

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reference competences is made. For this purpose, the active-passive-grid divides four areas, which enable a categorization of the reference competences:

- **Bridge competences** have high active and passive totals and are correspondingly strongly interlinked with the other reference competences. They must always be considered in conjunction with other reference competences and built up first.
- A high active total with a low passive total of driving competences at the same time indicates a medium degree of interconnection. **Driving competences** influence other competences without being strongly influenced themselves. They have to be built up according to bridge competences and before isolated competences.
- **Driven competences** are characterized by a high passive total and a low active total. With a medium degree of interconnection, they are mainly influenced by other competences. Driven competences should be built up before isolated competences and after bridge competences.
- **Isolated competences** have an overall low degree of interconnection. Due to the low active and passive totals, island competences can be viewed in isolation and built up last.

By categorizing the competences, a sequence can be determined for the structure of the competences. Taking this sequence into account, the competences may be transferred into a development path and networked with each other. This so-called competence development path only contains competences that are not yet existent in the company under consideration. Therefore, a gap analysis for smart service-specific competences is carried out.

As the result of this phase, a smart service-specific competence roadmap plots all smart service specific competence development paths over time (Figure 10).

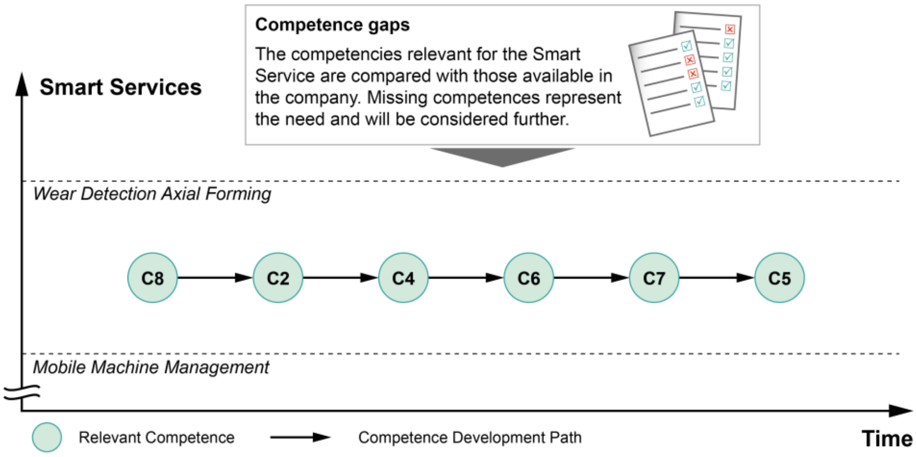


**Figure 10** Competence Development Path for “Wear detection for cold forming dies” (excerpt for Provision)

*Value Creation Planning*

This phase consists of three consecutive steps. The first step is to evaluate the strategic relevance for the identified competences. Additionally, their accessibility is to be derived. The combination of the first two steps finally leads to recommendations for action for competence-based value network planning. The described procedure will be discussed in more detail below.

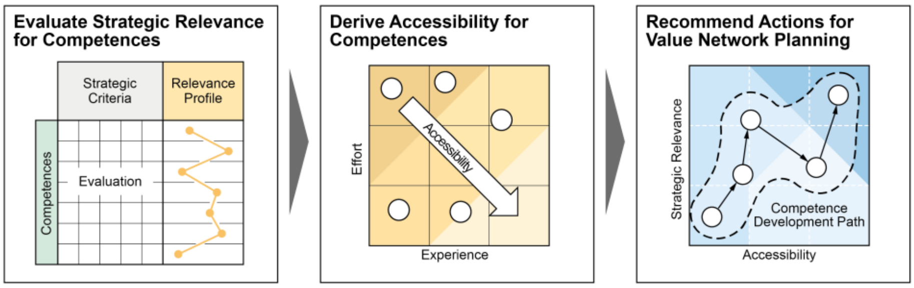


**Figure 11** Three steps to recommendations for value networks

For the strategic relevance, a relevance profile of the competences specific to the smart service is determined. The relevance profile matches the competences with strategic criteria, distinguishing between internal and external criteria according to Rübbelke (2016). Internal criteria can be, for example, the frequency of use of a target competence in company-specific processes or the strategic fit from the point of view of the company. External criteria include, among others, the potential for differentiation from competitors or the innovation potential resulting from the development of a competence.

The accessibility of smart service-specific competences is derived with the help of a portfolio. This portfolio includes the effort required to develop a competence and the experience available in the company regarding a competence. The development effort is derived considering monetary and temporal requirements. Workshops and interviews are conducted to evaluate the experience of the considered company with reference to the competences to be evaluated. In this way, self-assessments and external assessments allow conclusions to be drawn about the competence-specific wealth of experience.

To finally derive recommendations for action for the competence-based planning of value networks for smart services, the allocation of the identified competences must be anticipated. The competence portfolio shown in Figure 11 represents a tool for competence allocation. It links the competence development path with the strategic relevance and accessibility of its competences. Against this background, the competence portfolio is divided into three areas according to Kage and colleagues (2017), from which recommendations for action can be derived for the allocation of the competences arranged in it:

- **Strategic partnerships**: Competences in this area are difficult to achieve for the considered company. However, they are of high strategic relevance. The company has to establish strategic partnerships in order to develop the competences.
- **External handling**: Competences in this category have low to medium accessibility and are not of high strategic relevance. Therefore, external processing via service providers or suppliers is recommended.

- **Internal handling**: The accessibility of competences in this area is generally high. Irrespective of the strategic relevance, these competences must be developed by the company itself.

Based on the allocation of competences, further recommendations for action can be derived for the planning of value networks for smart services. As soon as a company has to enter into strategic partnerships to build up one or more competences, intensive inter-company cooperation is a prerequisite. The design of the value creation network should focus on critical inter-company relationships, so-called critical paths. Particular attention should be paid to these in strategic planning, especially with regard to communication, information and coordination.

External handling of competence requires a special focus on the design of the interactions of all partners in a value network. The relationships within the value network should be differentiated in particular with regard to the exchange of services, finances, information and data. Both between the considered company and partners as well as between the partners among themselves.

In contrast, internal handling of competences requires a focus on internal aspects. Particular attention should be paid to the operational and organisational structure of the considered company. New roles such as data scientists should be taken into account.

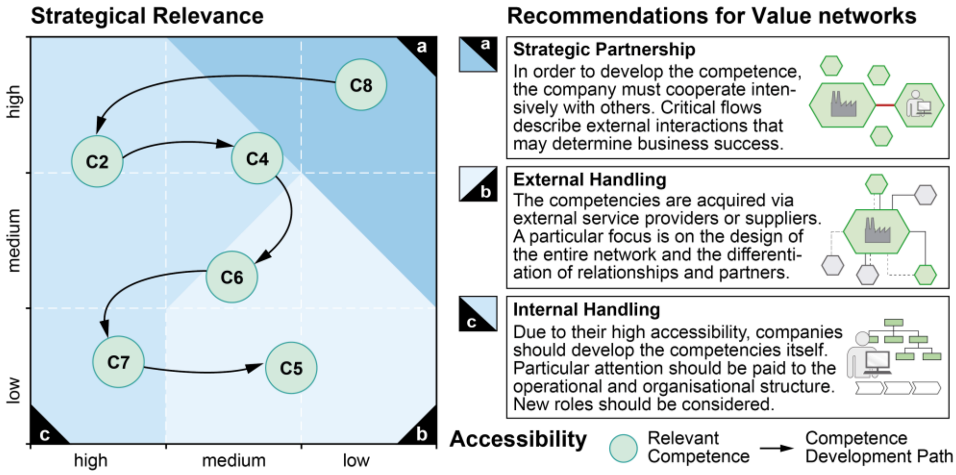


**Figure 12** Competence-based recommendations for value network planning for “Wear detection for cold forming dies” (excerpt for Provision)

## 5 Summary and Conclusion

Today's manufacturing industry is confronted with a fundamental change in value creation. The main drivers are the megatrends of digitalization and servitization. The tension between the two megatrends leads to new hybrid market offerings, so-called smart services. Smart services and the highly complex transformation of value creation raises major challenges for the strategic planning of value networks. Especially small and medium-sized companies often lack sufficient competences and resources to implement smart services on their own. They must consider opening their boundaries and collaborating with partners to develop and provide smart services. With the paper at hand, we propose an approach to fill this research gap. First, an introduced framework for smart service planning links strategical, tactical and operational competences with six different planning elements regarding four required dimensions of socio-technical systems. Second, our methodology sets up on the framework and provides a process model for the competence-based planning of value networks for smart services with recommendations for actions as results. During our research and accompanying project work we made general findings as well: 1) We identified the need for competence-based planning of value networks for smart services in the context of our case study. 2) Iterations in the implementation of smart services are indispensable. Future research should address this issue. 3) The development of competences following their logical sequence leads to different stages of value networks. Methodological support is needed to consider planning value networks in stages.

## 6 Acknowledgement

The research findings in the paper at hand are the result of a cross-project exchange and close cooperation between two different joint research projects. On the one hand, research was conducted in the joint research project Instruments for pattern-based planning of hybrid value creation and work for the provision of smart services (IMPRESS). In addition to the University of Paderborn, 2 other research institutes and 7 mechanical and plant engineering companies are participating in the project. The IMPRESS project (02L17B070) is/was funded by the Federal Ministry of Education and Research and the European Social Fund within the context of the programme "Innovations for tomorrow's production, services and work: the future of work" ("Innovationen für die Produktion, Dienstleistung und Arbeit von Morgen: Zukunft der Arbeit"). On the other hand, the method developed is based on the preliminary work of the project Instruments for the Performance Improvement of Enterprises by Industry 4.0 (INLUMIA). In 6 pilot projects with industrial partners, the instruments are validated or applied, thus sustainably strengthening the competitive position of the pilot users. The joint project consisting of 11 partners is supported by funds from the European Regional Development Fund NRW (EFRE.NRW) with a funding volume of around 2.5 million euros.

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