Development of Business Model Families for Product-Service Systems

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Abstract

To access new market segments, a growing number of manufacturing companies are changing their business models and are transforming themselves into providers of so-called Product-Service Systems (PSS). These are a combination of product and service components. Since a complete transformation of the business model often involves uncertainties and risks, companies often offer different types of PSS simultaneously. However, this increases the variety and thus the variety-induced complexity for the companies. Therefore, this paper introduces an approach that allows the development of suitable PSS-based business models that can be offered simultaneously as a business model family and are based on existing products. The approach is applied to the example of a manufacturer of industrial valves.

Keywords

Product-Service Systems, PSS, Variety, Business Model Family

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1. Introduction

Manufacturing companies are confronted with the challenge of continuously increasing cost and individualization pressure due to globalization [1, 2]. One solution is to further diversify the product portfolio and offer increasingly personalized products [3]. Alternatively, manufacturing companies can transform themselves into providers of so-called Product-Service Systems (PSS). These consist of physical products enhanced with a set of related services to provide a solution to customers [4–8]. PSS as an offer are directly linked to a company's business model. For this reason, the two topics are becoming more frequently discussed together in the literature [5, 6]. Besides, it becomes increasingly relevant for companies to consider requirements from the later life phases in their development process to a greater extent [9].

So, PSS provide a way out of cost pressures for companies and open up multiple advantages [8], however, they entail challenges in their implementation. The most frequently mentioned challenge in literature is the increase in complexity [7, 10], caused by the integral handling of product and service components. Complexity drivers in this context are diverse, but may often be traced back to an increase in variety within the company [7, 11]. This issue can be addressed by modularizing the PSS [7, 12, 13], which is why the integration of service architectures has become increasingly relevant in the field of modularization research [14, 15].

Figure 1 schematically illustrates the connection between PSS-based business models and the corresponding product and service architectures. In a very product-oriented business model, a high degree of variety is required on the product side in order to configure various product variants for customers (1). However, if the business model shifts toward services, the product is only needed as an enabler for the services and can accordingly be designed from a higher proportion of standard components (3). The variety required to differentiate the offering is achieved via the services, which are significantly more complex than in (1). This interaction can be used for complexity reduction in PSS [16, 17].

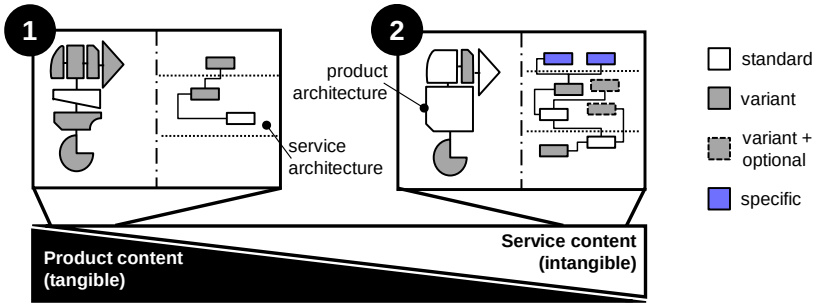

Figure 1: Relation between PSS-based business models (horizontal axis) and product and service architectures [16, 17]

In practice, many companies will not completely transform their business model, as the PSS-based business models should be designed differently for each customer [18]. This adds to the complexity, as offering PSS-based business models and traditional products simultaneously is a challenge for companies [19]. Therefore, the objective of this article is to outline how to develop a family of PSS-based business models and the corresponding product architecture so that different customer segments can be offered the appropriate PSS without increasing the internal complexity in the company more than necessary.

2. Research Method

This research is based on the DRM approach [20]. First, a literature review is conducted to clearify the research goal and evaluate existing approaches for the design of PSS. Based on this, a new approach for the design of PSS-familes is iterativly developed and applied in an industrial context within a reseach project. The industry feedback of each step is used to

improve the approach. For documentation purpose, the developed approach is schematically described in Section 4, followed by the results of the case study in Section 5. Afterwards, the results are critically discussed in Section 6. The paper concludes with an short outlook on further research topics in Section 7.

3. Literature Review

First, a few definitions are given to harmonize the understanding if the used terms in this paper. Variants (of a product) are technical systems with similar structure and function that are offered simultaneously. They often use a high proportion of identical components that differ in at least one characteristic [21]. All variants based on similar functions, technologies or area of application can be summarized as a (product) family [21]. There exist various definitions for business models, but in general they all describe a business model as the mechanism of a company to create value [22, 23]. The mechanism is composed of components, so that the given definitions for *variant* and *family* from product perspective, can also be applied for business models. Similar to a product family, that summarizes a set of product variants that differ in their charateristics, a business model family consist of business models that differ in their scope and revenue mechanism.

There exist various approaches in literature that deal with the topic of PSS development, e.g. with the development of modular PSS [24]. In this context the approaches are relevant that deal with the design of PSS and their corresponding business models. Examples for approaches dealing with PSS and business model development include [25–29]. Each approach has strengths and weaknesses and addresses different aspects of business model development for PSS. For example, the focus of Reim et al. is on digital business models for PSS [26]. What the above approaches have in common is that they primarily focus on the development of individual business models. To develop a family of business models, the approaches would have to be iterated. The development of multiple business models is addressed by van Ostaeyen et al. but this refers more to the expansion of the business model scope over time and less to the parallel offering of multiple business model variants. [30]. A method that directly addresses PSS family design is proposed by Sakao et al. but here the focus is set on the optimization of existing PSS families rather than the development of new business model families [31].

Summarizing, there is a lack of an approach in the existing literature that methodically supports the development of simoultaniously offered PSS business model variants, a so-called PSS family. To close this gap, a new approach is developed and presented below.

4. Developed Approach for the Design of PSS-Families

In this Section, the approach for developing business model families for PSS is generically described. The approach involves three steps. In the first step, the business model concepts are developed. In the following step, a functional decomposition of the PSS concepts is made, to identify the functional elements of the business model family. This is used for the third step, in which the functional elements are mapped to product and service components of the PSS.

4.1. Developing PSS-Concepts

The first step is to develop PSS concepts. These describe the extent and content of a PSS, in other words the underlying PSS-based business model, without including detailed solutions for implementation. The four dimensions according to [32] can be used to describe the concepts. They are shown in Figure 2 and will be explained in the following. In this article, the focus is on how to develop the *How* based on the *What*, *Who* and *Value* so that the internal complexity for the company is minimized as much as possible.

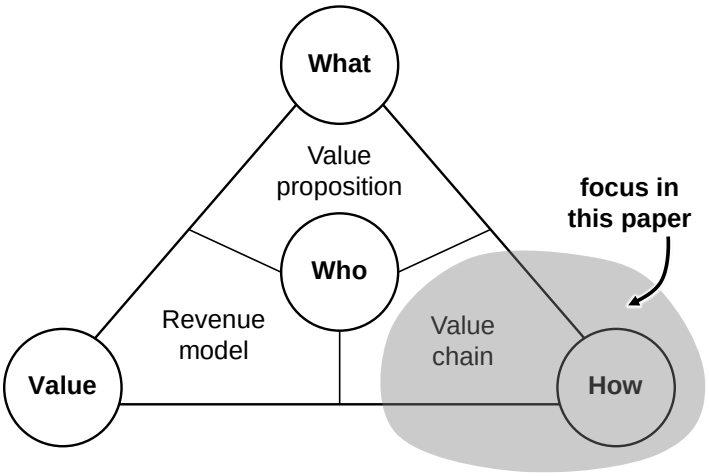

Figure 2: Four dimensions of a business model according to Gassmann et al. [32]

The target group (*Who*) is the core for the PSS concept. However, it is often not possible to define a homogeneous target group for a PSS. Instead, different PSS variants are offered for different customers simoultaniously [18]. In addition, companies face the challenge that new customers should be targeted by PSS, which currently cannot be described accurately. Furthermore, PSS may be offered in the future rather than immediately, so it should be thought ahead. To deal with these uncertainties, it is suggested to predict the development of the markets in the future by means of a methodical foresight. Various approaches exist in the literature for this purpose, for example scenario management can be used here [33].

Other essential dimensions are the *What* and the *Value*. These describe what is to be offered to customers and how the revenue mechanism is designed. For the development of the *What*, the *Business Model Graph* according to Rennpferdt et al. [16] can be used. As further input, the *B2B Elements of Value* [34], the *Proteus PSS Morphologie* [35] or the overview of PSS [36] can be used. For the elaboration of the revenue mechanisms, for example the approach of van Ostaeyen et al. [30] may be applied.

The most relevant dimension for the design of the PSS architecture is the *How*. This dimension includes the implementation of the PSS in product and service components. An important aspect in this context is the fact that existing approaches usually focus only on the development of a specific PSS and neglect that in practice often a family of PSS-based business models has to be offered (see Section 3). Therefore, this paper will present an approach that considers parallel offered business model variants and their implementation in product and service components when finding solutions. In this way, it is possible to develop a PSS architecture that allows a PSS provider to offer various PSS-based business model variants on the basis of a minimum number of product and service components.

4.2. Functional Decomposition of the PSS concepts

The next step is the decomposition of the main demand into functions and subfunctions. The goal here, similar to what van Ostaeyen et al. [30] suggest, is to get from the demand level to the functional level. This helps to answer the question of what the customer wants and how this objective can be achieved. The *B2B Elements of Value* [34], the *Proteus PSS Morphologie* [35] or the overview of PSS [36] are used as input. However, a new aspect of the approach is the division between the product domain and the service domain. This is done in the *PSS family functional structure*, which complements a turnover-oriented functional structure on the product side with a representation of the service blueprint on the service side [11]. This set-up allows to show the interactions between the domains and at the same time to represent the functions of all business model variants, since optional or variant functions and activities can also be represented [11]. The schematic structure is shown in Figure 3.

In order to keep the variety and thus the variety-induced complexity low, the aim is to increase the process commonality as much as possible. This means that when searching for suitable functions and activities, attention should be paid to the fact that they cannot be used specifically for individual PSS variants, but rather across all variants in the business model family. Particularly in the area below the line of visibility on the service side, only standard activities and processes should be used, if possible, since the customer does not perceive these activities and therefore a variety at this point does not represent any added value for customers.

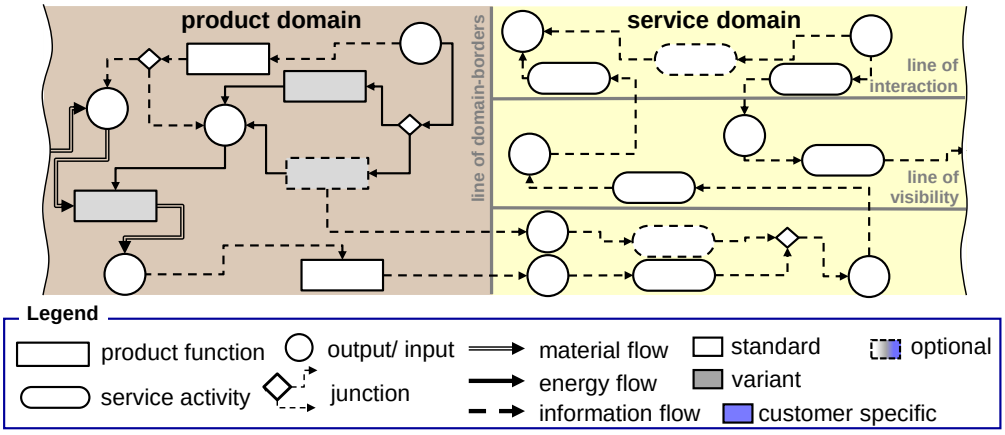

Figure 3: Connection of product and service domain in the PSS family functional structure [11]

4.3. Developing the PSS-Architecture

For the development of the PSS architecture, product and service components are assigned to functions and activities in this step. This step can be based on existing methodical approaches of product development, such as *VDI 2221* [37], the approach according to Pahl and Beitz [38] or other methods from PSS design, e.g. mentioned in [39]. The starting point for this step can be existing products or product architectures that already exist in the company. The result of this step is a PSS architecture, i.e. the assignment of business model variants and the corresponding product components and service activities. While the service structure is represented in the *PSS family functional structure*, the *Module Interface Graph* (MIG) is used for documenting the product components [40]. This is shown in Figure 4 and contains the components that are contained in the entire product family, as well as their classification into standard or variant components. In addition, the flows between the components are contained. The MIG can be used among other things, in order to form modules following this approach.

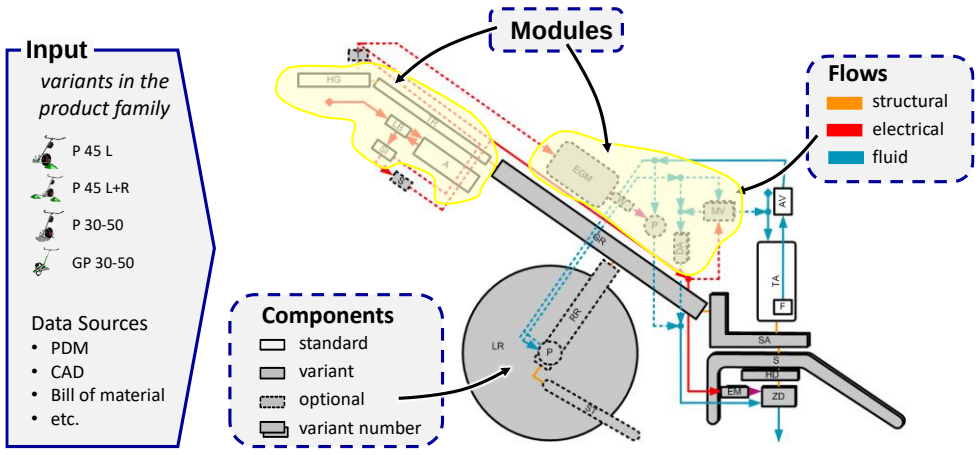

Figure 4: Module Interface Graph for a product family of spraying devices [2, 21]

5. Case Study - Application of the Developed Approach

The approach described is applied to the example of a product family of pressure reducing valves as part of a research project. The objective of the project is to anticipate possible PSS-based business models in the context of a new development of a modular kit and to consider the resulting requirements for the development of the pressure reducing valves. Therefore, different PSS-based business models are developed and their effects on the product architecture are analyzed. Due to confidentiality reasons, the results of the case study are only presented in excerpts hereafter.

5.1. PSS-Concepts for Smart Industrial Valves

In the first step, business model concepts were developed. For this purpose, the *Business Model Graph* was used (see [16]). The business model concepts were developed starting with an analysis of current customers and customer inquiries in sales, an analysis of the market, and an analysis of the future development of customer groups using customer and market scenarios. Figure 5 shows an excerpt of the results. In addition to the existing business model, the traditional sales-only (BM1), two PSS-based business model variants are used as examples below. On the one hand, this is the use oriented valve leasing (BM2) where the company leases the valves instead of selling them. This offer includes the maintenance and the adjustment of the valve characteristics when the customer changes the plant parameters. The second new business model is the availability guarantee of the valves (BM3). Here the revenue is generated by offering the customer a pressure adjustment solution including hints on how to adjust the plant parameters to optimize the efficiency.

Furthermore, a functional description was created for the identified business model concepts. This contains the main functions required to fulfill the value proposition included in the business model. This description of the customer demands serves as an input variable for the next step of the approach. The main function in case of the valves is providing a predefined pressure in the pipes behind the valve what can also be describes as *pressure control*.

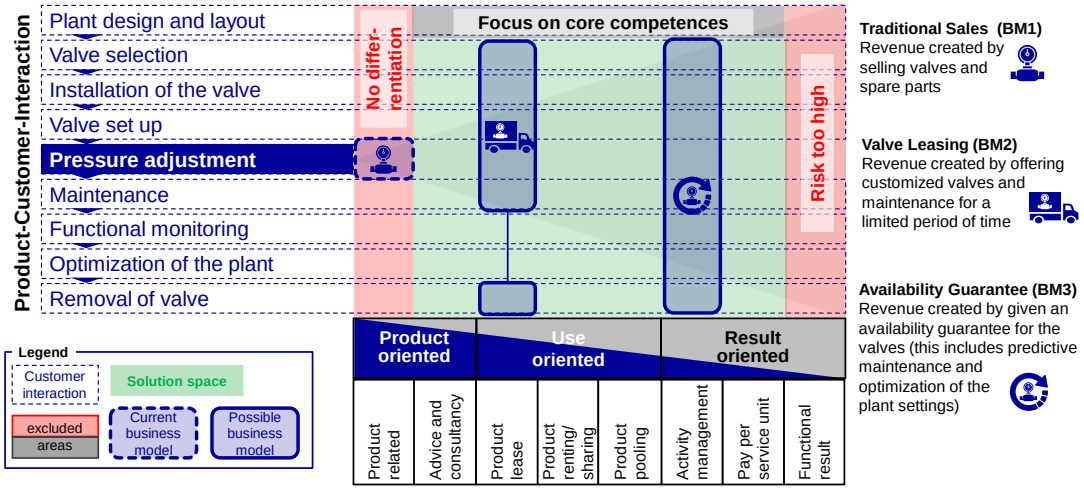

Figure 5: Business Model Graph for the industrial valves with an excerpt of the identified business models

5.2. Functional Decomposition of the Smart Industrial Valves

For the previously developed PSS concepts of the business model family, the functional structure is developed in the second step. For this purpose, the main demand that provides value for the customer, namely pressure control, is subdivided into main functions and sub-functions. An excerpt of this analysis is shown in the upper left corner in Figure 6. The symbols introduced in Figure 5 indicate which sub-function is required for which business model variant.

While the function *Compare pressure and spring load* is required for every business model variant, other sub-functions such as *Perform maintenance* or *Analyze operational data* are only required by two or one business model variant.

These sub-functions are then converted into a description of the required product functions and service activities, which are shown in the *PSS family functional structure* in Figure 6 below. In this representation, the elements required to implement the different business model variants can be identified. Starting point is the functional structure of the previously offered mechanical pressure reducing valves shown in area (1). The activities required for the administrative handling of the PSS-based business model family are shown in area (2). These include, for example, consulting the customer and preparing the contracts. These activities are required for each business model variant and are therefore a standard element within the business model family.

Area (3) contains the logistical processes required for the *Removal of valve* service offering. For instance, this includes the removal of the valve at the customer's site with subsequent return shipping to the provider, as well as the inspection and, if necessary, remanufacturing of the valve after leasing for reuse. This area is only required for the two business model variants BM2 and BM3, not for the traditional sale (BM1). Area (4) covers the analysis and preparation of recorded measurement data. This is done largely invisible to customers. Within BM3, they receive only the results of the analyses. To analyze the data, they must be recorded and sent in the first place. For this, additional product-side functions are necessary, which are shown in area (5). However, these are only required if customers also request the associated business model variant BM2 or BM3. These functions are not required for the traditional sale of valves (BM1), but they can represent an additional value in the future and additional revenue.

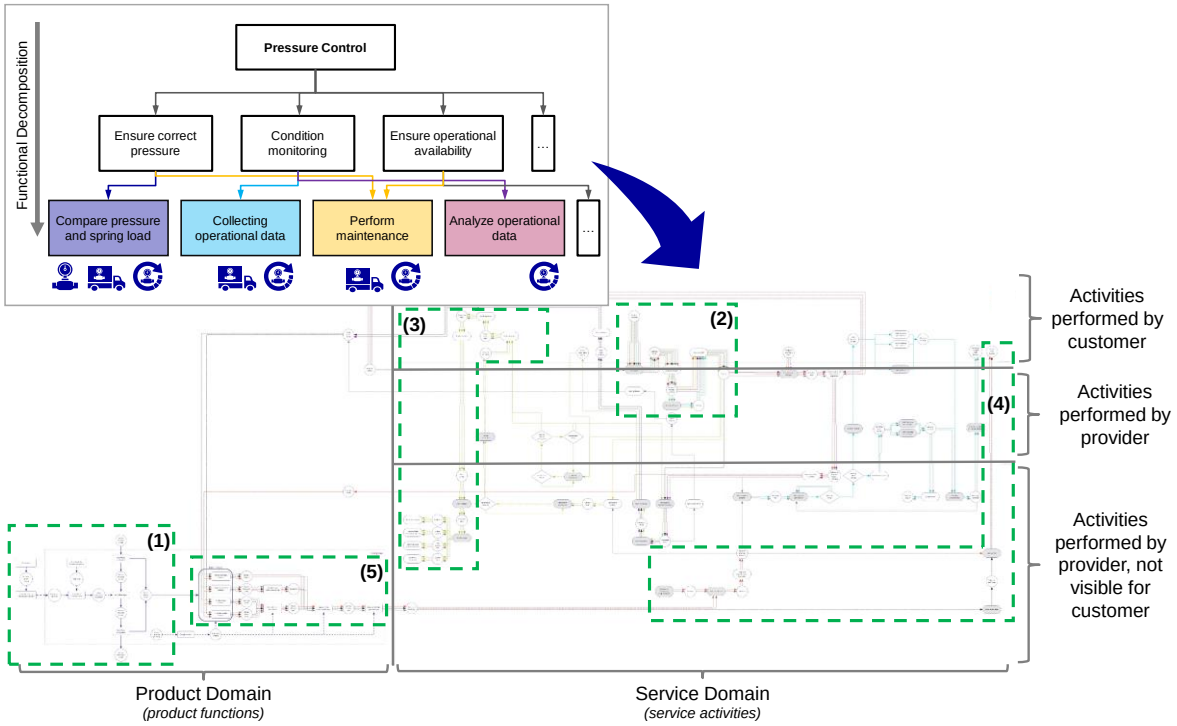

Figure 6: Functional structure of the business model family separated in product and service domain

5.3. PSS-Architecture for the Smart Industrial Valves

Once the required product functions and service activities for the business model family have been developed, the third step is to translate the functions into components. The result for the case study is shown in Figure 7. The left-hand side shows the product components required to fulfill the respective business model variants. For traditional sales (BM1), the

existing product is required (1). If leasing is offered (BM2), additional sensor technology must be installed to measure and transmit data, as described above. For condition monitoring, a sensor for recording the stroke movement and a unit for data recording are required (2). If even more data is required for the business model variant BM3, additional sensors are installed in the valve (3). In order to implement the business model family with as little variety as possible on the product side, the *Data processing unit* (see Figure 7) is developed in such a way that it can be used for BM2 and BM3. Although this is oversizing, it significantly reduces the variety. The sensor components will be designed so that they can be easily mounted to locations on the main body that are covered with plugs when not needed. This results in the product architecture is shown at (4) on the right side. Depending on the functional scope of the business model variant for individual customers, the associated sensors are additionally installed or not. This means that a wide variety of PSS-based business models can be implemented on the basis of a uniform product architecture without having to develop new products or product components.

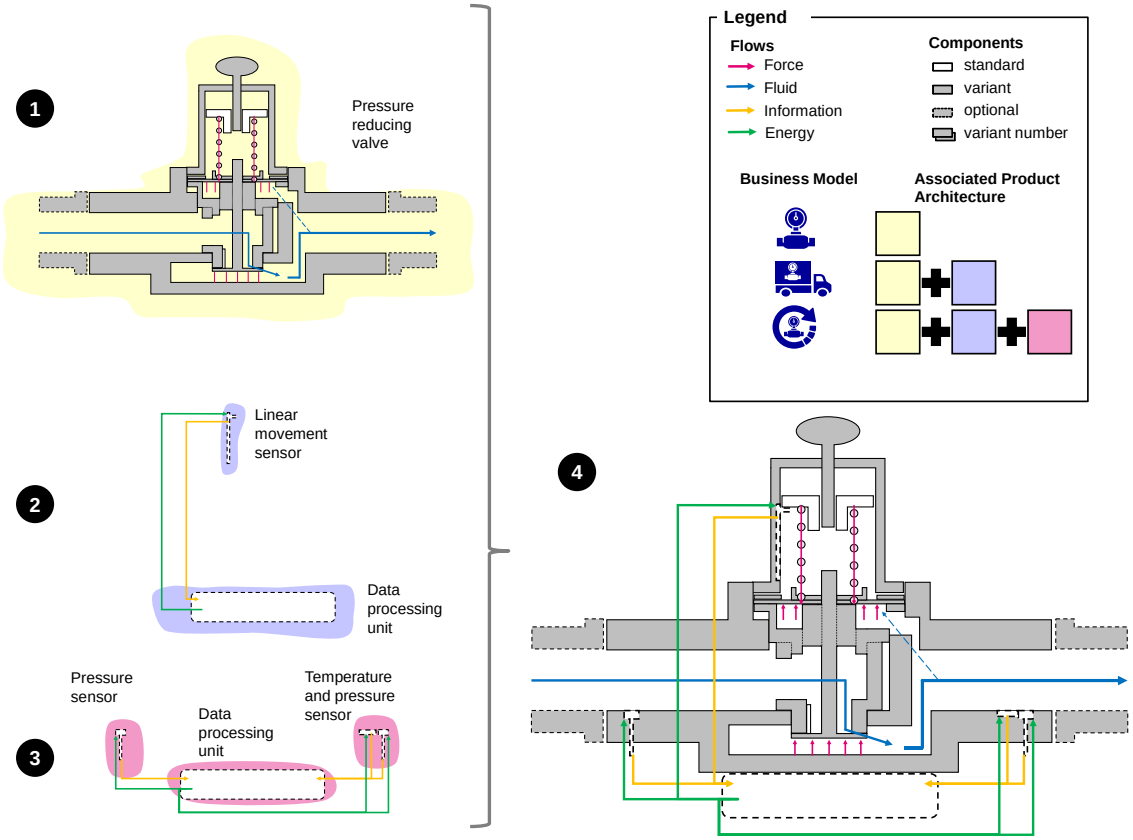

Figure 7: Excerpt of the PSS-Architecture mapping

6. Discussion of the Approach and the Case Study

The approach presented has led to useful results for the pressure reducing valves. Economies of scale can be achieved by using a PSS product platform which is as standardized as possible and which can be extended to include additional components if necessary. This is particularly helpful when the demand for PSS is still subject to uncertainties and the expected sales cannot be predicted.

For applicability to other products, the steps of the approach need to be further elaborated and detailed. One example is the functional decomposition in Step 2, as this is very case-dependent and was developed through many iterations within the case study. Another example is the mapping of functions and product architecture. More support is needed here, especially if it is a more extensive new development.

7. Conclusion

This article presents a first outline of an approach for the development of families of PSS-based business models. For this, a literature review was conducted first to confirm the research gap. Subsequently, a new approach was developed and applied in the context of a research project in a company. With the help of the new approach, several PSS variants and the corresponding PSS architecture could be developed. However, in order to be applied to other products and to be validated, the new approach needs to be further elaborated and detailed.

In addition to detailing, it should also be investigated how the approach can be linked to methods for the concrete design of PSS, e.g. the variety-oriented design of PSS or modularization of PSS [7, 11, 13]. This could reduce the variety of PSS components even further, ultimately enabling even greater benefits for companies.

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