Service Classification to Support Planning Product-Service Systems

Danilo Marcello Schmidt
Institute of Product Development
Technische Universität München, Germany
danilo.schmidt@pe.mw.tum.de

Oliver Malaschewski
Institute of Product Development
Technische Universität München, Germany

Matthias Jaugstetter
Institute of Product Development
Technische Universität München, Germany

Markus Mörtl
Institute of Product Development
Technische Universität München, Germany

***Abstract*—As Product-Service Systems (PSS) are capable to provide more specialized offers to customers, an appropriate design of PSS influences aspects of customer acceptance. The differentiation within PSS-offers bases on services and it requires the switch from offering pure product to offering PSS. Especially traditional companies who offer pure products without additional services must meet the challenge of servitization. To support those companies in planning PSS, we developed a service classification model. For this, we first analyzed existing classification taxonomies from various authors and identified existing service offers. We aggregated the identified services and optimized the number of services using a clustering algorithm. The result is a classification model of services, which helps PSS-planners to identify suitable services for their products.**

Keywords*—product-service systems; services classification; service identifcation; service clustering

I. Introduction

Product-service systems (PSS) are an auspicious approach to influence aspects of customer acceptance. Product-service systems consist of physical, mostly tangible products and intangible services [1]. These two parts do not exist separately, but have to be developed, designed and created simultaneously with all interdependencies and necessary infrastructure. According to various authors, PSSs are capable to better meet customer requirements, to provide more sustainable products and to increase customer loyalty [1-3]. The differentiation between various product-service systems is thereby mainly done with the additional service offering [4]. In literature, a lot of approaches, methodologies and framework exist for designing PSS from different perspectives [5-16]. Schenkl [15] focuses knowledge-related aspects, van de Kar [8] gives more weight to the customer integration and Hepperle [16] analyzes the implications of the lifecycle-phases on the PSS-development. Even for developing business models and services, the literature provides supporting approaches [17, 18]. Beyond those processes and methods, which serve as supporting frameworks for designers, practitioners have to meet the challenge to identify what kind of services they should include in the PSS-offer. While the mentioned approaches provide a more processual support, they do not suggest possible options for business models or services. More concrete support for PSS-designers is missing, which is comparable to constructions catalogues for mechanical products. This work is a first step into developing a construction catalogue for PSS by building a service classification. This classification scheme can serve as a checklist for PSS-designers. This enables PSS-providers to identify and select promising service solutions. The service classification supports companies providing PSS, which are based on a complex technical product, while adding services to the pure product will increase the customer's benefit of the market offer. Those companies might deal with plant manufacturing, machine tools, production machines, construction machines, energy and power.

In this paper, we first review the literature for existing service classification models. Then, we identify services from literature and industry. After aggregating them, we set the dependencies between the services and customer functions. Those dependencies facilitate to cluster the services. This clustering structures the services in a way that they are easily applicable by practitioners. After describing the resulting service classification, we complete the paper with a short conclusion and outlook.

II. State of Research

The literature provides several approaches for categorizing services [1, 19, 20]. Tukker's classification of PSS is also applicable for services [1]. It considers how PSS are offered and differs between product-oriented, use-oriented and result-oriented PSS. Other sources like [20] provide a similar categorization, they also mention information-based services or process-focused services. White and Stoughton [19] differ between non-material services and material (i.e. product-based) services. Kapletia and Probert [21] divide services concerning their aims. Beyond providing final results, enabling platforms or added value to the product life cycle, services orientate the product, customer or the relations [4]. Those service categories are an abstract classification of services, most of them origin from the PSS-research. However, they are on a too abstract level to support practitioners in finding new services.

Existing approaches describing service ontologies provide also ontologies for classifying services [22-25]. Hepp [23] defines product and service classes, which provide same functionality and which are used for same targets. He only focuses web-services and mentions criteria like “payment method”, “validity” or “business entity type” to differentiate between services. The service ontology approaches only focus web-services and are not applicable for the industries mentioned in the introduction. Furthermore, ontologies do not suggest new and concrete services, they are used for structuring services. Also service taxonomies [26-29] are only used for the differentiation of services by defining criteria on several levels. Höfer and Karagiannis [26] focus services for cloud-computing and define criteria like “license type” or “security measures”. By defining different scales for the criteria, taxonomies can be used to identify new services. This way of identifying new services is not easily applicable for practitioners, as they first have to understand the taxonomy and derive their services from the taxonomy. Additionally, the service taxonomies are mostly focusing web services [26, 27] or pure service industries [28, 29]. However, they do not consider the industries we focus in this work.

In our literature research, we found 11 sources, which mention concrete services: Goedkoop et al. [30] analyzed PSS-offers of ten companies. From this, we extracted concrete services like “maintenance” or “needed accessories”. Roy [31] also considered industrial cases like a producer of copiers. He assigned services to the PSS-categories, he identified before, e.g. “repair” or “supply of consumables” are result services. Mont [32] carried out a study of literature on product-services and eco-efficient services. In this context, she identified services typical for PSS. One main service is hereby “maintenance”. At the end of the product’s life cycle “take-back agreements” and a “recovery”, “reuse”, “refurbishment” and “remanufacturing” of the product are sensible approaches. Morelli [33] carried out an analysis of a certain customer group who might use a telecenter. He found services like “financial services” or “technical assistance”. Oliva and Kallenberg [34] investigated eleven “[…] capital equipment manufacturers developing service offerings for their products” [34]. They identified existing product-related services like selling and maintenance in the first phase. Besch [35] examined, similar to [30] the usability of product-service systems for office furniture. Therefor she identified services, which are useful in this context. She found services like “remanufacturing” or “spare-planning”. Aurich et al. [9] focus on the development of a systematic design process for technical services of product-service systems. Different service solutions emerged when they stated properties technical services have to fulfill. Services like “inspections”, “preventive maintenance” and “repair” ensure products to provide its designed power and functionalities [9, 36, 37]. Furthermore, customers expect services like “maintenance”, “upgrading”, “user trainings” and “process improvements” more often [37]. Oliveira and von Hippel [7] investigated commercial and retail banking services. Despite the fact that the main scope of this work was to identify services which can be self-provided, we were able to derive services relevant for product-service systems as well. Hereby, we had to adapt some of the services that can be used on technical products. E.g. “consumer forums” and “communities” can be offered, where problems with a specific product can be discussed. Gaiardelli et al. [20] proposed a new classification model for product-service offerings. To apply their model in an empirical study, they first identified product service offerings and clustered them according to the dimensions proposed by [1]. One service is the “delivery of products”. Providers can support customers by offering different “financial services”, which make customers able to afford a new product.

The described sources come up with concrete services suggested for various industries. All of them mention a few services and present how they can support the customer or extend the product life cycle. However, those approaches are focused on special industries and they suggest services on a quite abstract level: They do not provide a broad collection of services. Those approaches are useful for a first draft for the service classification. However, to serve as a valuable checklist for PSS-designers, this list has to be enlarged. For this reason, we started from this list of services identified in literature and extended them by analyzing existing service offers from industries. Searching services in offers from industry might not guarantee that all possible services will be identified. However, by including services from industry, we can provide a model of services, which includes a broader span of services.

From this, we derive our research questions. First, we want to identify as much services as possible, which might be offered in our focused industry. Therefore, the first research question is:

What kinds of services embedded in a PSS exist in literature and in real offers for the industries plant manufacturing, machine tools, production machines, construction machines, energy and power?

Furthermore, we want to make this collection of services applicable for PSS-planners. We expect to identify a very high number of services and services, which might be on a level of abstraction that is not useful for practitioners. To increase the applicability of the collected services, we have to aggregate them and to bring them to a suitable level of abstraction.

How can the identified services be aggregated and processed, that they serve as a checklist to support practitioners in finding new services?

III. Building a Service Classification Model

The proceedings to build the service classification consisted of five steps: The first step was to identify services from literature and from existing service offers. The identified services were aggregated by eliminating and summarizing redundant services. We pre-clustered the services to make the step easier to model the dependencies between services and customer functions, which happened afterwards. To build the service classification, we clustered the services according to their relations to the customer functions, which led to 63 service-clusters. This procedure is shown in figure 1. In the following, we explain the steps on a more detailed level.

A. *Identifying existing Service-offers*

The first step was to identify a high number of services to facilitate the service classification model to cover a broad spectrum of services. For this, we searched in literature and in industrial services offers. We analyzed 11 papers, which deal with services and PSS from different perspectives to identify services (see State of Research). In these sources, we identified 193 services. The authors did not present the services as a service offer but from a more neutral perspective. As opposed to this, the services identified in the offers from companies were presented as offers for their customers. While the authors described the services more detailed, the companies presented the services to convince their customers. To analyze and consider the range of an existing service offer was quite challenging in some cases, as only the marketing term of the service was available. Thus, we cannot guarantee, that we understood every service in its whole range. However, we do not need a complete and granular understanding of services, as the service classification should serve as an inspiration method for PSS-planners. To identify service offers from companies, we first identified suitable companies. As we wanted to support companies providing complex mechatronic products and additional services, we selected enterprises from the following sectors: plant manufacturing, machine tools, production machines, construction machines, energy and power. To find the services, we searched the web pages and analyzed the product brochures of those companies. We identified 824 services from industrial companies, in total this identification step resulted in added together 1017 services.

Table 1 shows a small excerpt of the identified list of services. As 1017 services is a too high number to be handled by practitioners and as several services described the same performance range, we decided to aggregate the services in a next step.

TABLE I. IDENTIFIED SERVICES (EXCERPT ONLY)

Source	Service
Alzmetall (2015) [10]	Advisory
Pfeiffer (2015) [11]	Analysis
Wirtgen (2015) [12]	Analysis
Alzmetall (2015) [10]	Calibration
Samhammer (2015) [13]	24/7 Call center
OTIS (2015) [14]	24/7 hotline
…	…

B. *Compromising and aggregating identified Services*

As the services identified in the first step are just a raw collection of services, some of them are duplicates or on a too abstract or too concrete level. For this, we eliminated duplicates (concerning the service names) and reduced the number of services from 1017 to 380. Furthermore, we removed 32 Services from the list because of they are too generic and too abstract, e.g. “full services”, “outsourcing”. 7 more services were eliminated because of being too abstract, which described a category of PSS according to [1]. Those services are too abstract to be helpful for practitioners in finding suitable services. We deleted 9 services, because they were too concrete about a certain business, like “car services” or “color mixing formulas”. Furthermore, we considered the performance range and the output of the services and removed 47 more services, which had the same performance range compared to other services. Using these aggregation mechanisms, we reduced the number of services to 265.

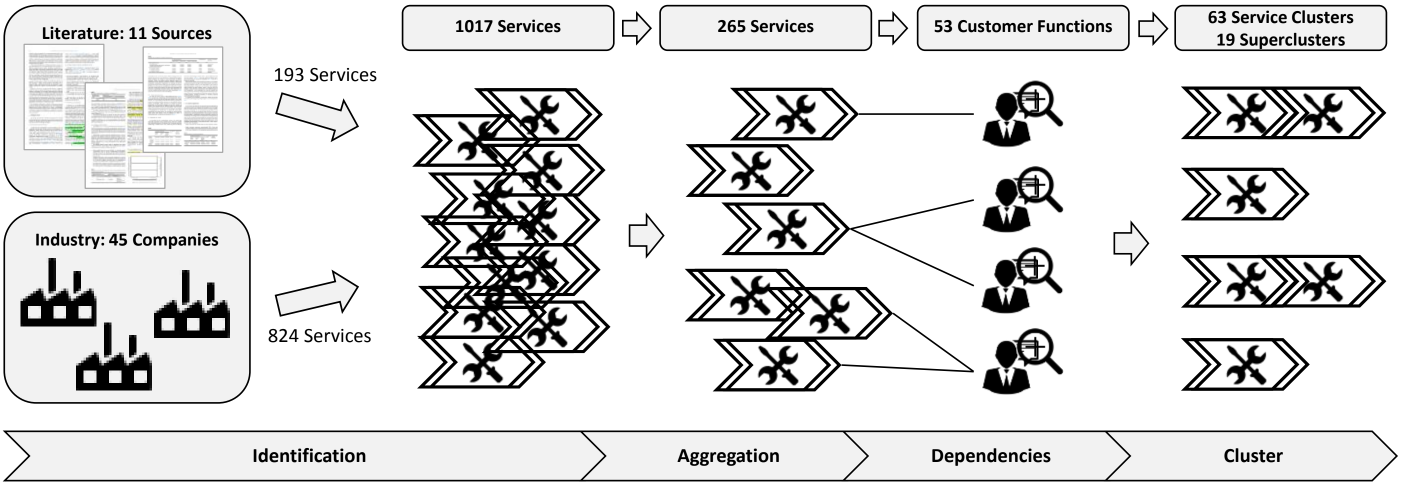

Fig. 1. Procedure for building the service classification model

C. *Preclustering and Modeling Dependencies between Services and Customer Functions*

As the number of 265 services is still too high to be easily handled by practitioners, we decided to cluster the services. For this, we need to interlink the services to each other, either directly or indirectly. The focus of the overall project is the customer acceptance and the service classification should serve as a checklist for PSS-planners to identify services for increasing customer acceptance. For this reason, we interlinked the services to customer functions. We define a customer function as the functional benefit the customer gains from making use of the service. For linking and clustering the services, we followed the procedure of structural complexity management (StCM) [38].

This procedure starts with the system definition by building a Multiple-Domain Matrix (MDM). Figure 2 shows the MDM consisting of the domains customer functions and services. The MDM consists of Domain Mapping Matrices (DMM), which connect two domains, and Design Structure Matrices (DSM), which shows the relations between the elements of the same domain. The DMM “Services-Customer functions” presents the only direct relations within this system. Calculating the indirect links between services based on the DMM “Services-Customer” functions generates the DSM “Services”. This DSM shows the relations between the services, while services are connected if they fulfill same customer functions.

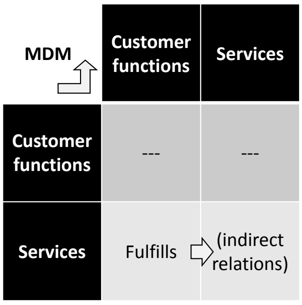

Fig. 1. MDM for services and customer functions

Before we set the dependencies, we conducted a manual clustering. The target of this pre-clustering was to order the sequence of the services. This had two advantages: First, setting the dependencies in the DMM “Services – Customer functions” is simplified, because similar services are processed in a row. Second, the cluster algorithm needs less iterations for clustering, because the services are in an order, which is closer to the optimized order than a random distribution.

To cluster the services, we defined three mechanisms for clustering:

1. Considering service A and service B, while the performance range of service B is completely included in the range of service A: Summarizing both services to a cluster consisting of the performance range of service A. Example: Service A: “Repairs”, Service B: “Repairing out-of-guarantee”, Cluster: “Repairs”.
2. Considering service A and service B, while the performance ranges of both services mainly overlap: Summarizing both services to a cluster consisting of the performance range of one of the services. Example: Service A: “Copying”, Service B: “Duplication Service”, Cluster: “Copying”.
3. Considering service A and service B, while a small part of the performance ranges of both services overlap: Summarizing both services to a cluster on a more abstract level, which includes the performance ranges of both services. Example: Service A: “Mechanical Design”, Service B: “Concept Design”, Cluster: “Design”.

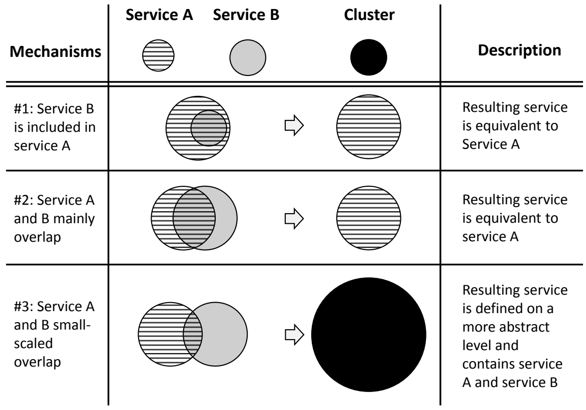

Fig. 2. Mechanisms for Clustering

For clustering the services, we did not only apply the described mechanisms for a single pair of services: In most cases, we summarized more than two pairs and we also combined the mechanisms for same services. This clustering resulted in 55 service-clusters. Figure 2 depicts the mechanisms for clustering services. Table II shows an excerpt of how the services were allocated to the clusters.

TABLE II. PRE-CLUSTERED SERVICES (EXCERPT ONLY)

Cluster	Service
Help desk	Help desk
	Helpdesk software
	Service desk
	Service help desk
Technicans	Qualified technicians
	Service engineers
	Technicans
…	…

The next step in the procedure of StCM is the information acquisition by identifying direct system’s dependencies. To link the services to the customer functions, we built a Domain Mapping Matrix (DMM) [38], consisting of the domains services and customer functions. For this, we first identified the customer functions by analyzing all services regarding their benefits for the customers. In total, 53 customer functions were identified, like “improve product usage”, organize suppliers” or “clean the product”. In a two-sections workshop, which took in total 9 hours, two students filled the DMM “Services-Customer functions” by setting the dependencies between all services and customer functions, which were 262 services x 53 customer functions. Of those in total 13886 dependencies, 422 relations were set. If the customer function is the main target of the service, a relation was set. However, when a service included a part of a customer function, which was not the main service’s target, no relation was set.

The target of applying StCM was to cluster the services. According to StCM, the next step is to deduce indirect dependencies. In this case, we calculated the DSM "Services" by squaring the DMM "Services-Customer functions". This DSM showing the indirect relations between services is based on the assumption in figure 3: If two services fulfill the same customer function, they are indirectly connected.

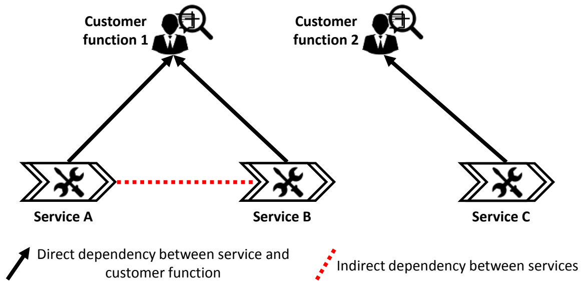

Fig. 3. Direct and indirect dependencies between services

After calculating the DSM "Services", we were able to cluster the services.

D. Clustering Services

The tools and methods for clustering are made for clustering Design Structure Matrices (DSM) [38], which models the dependencies between elements of the same domain. For this reason, we calculated the DSM showing the indirect relations between the services based on the customer functions. This DSM links services, which fulfill same customer functions. We used the Cambridge Advanced Modeller and its clustering algorithm (https://www-edc.eng.cam.ac.uk/cam/) to identify the service clusters. The parameters and iterations of the cluster method were set to reach around 60 clusters. We regarded this number of services as high enough to have a detailed and broad range of services for practitioners. Furthermore, this number of services is low enough that the service classification is usable in practice.

TABLE III. SUPERCLUSTER, CLUSTER AND SERVICES

Super-cluster	Cluster	Services
Guarantee	Price guarantee	Money-back guarantee
		Fixed prices
	Product guarantee	Extended warranty
		Guarantee even on wear parts
		Spare parts availability for at least 20 years
		Additional guarantee

An excerpt of the clustered DSM is shown in figure 4. The clustering algorithm resulted in 63 service clusters (yellow boxes in figure 4). We summarized those service-clusters to 19 superclusters (blue boxes in figure 4). Table III shows exemplary the clusters and the services for the supercluster "guarantee".

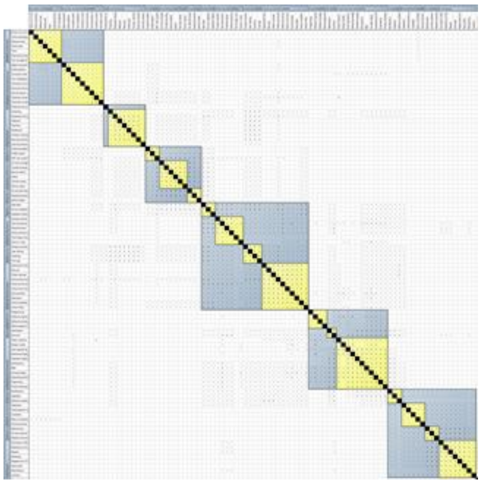

Fig. 4. Clustered DSM "Services" (cxcerpt only)

IV. CONCLUSION

In this work, we built a service classification to support practitioners in planning PSS to identify services, which are suitable for being integrated into the PSS-offer. Even though it covers a broad range of services, we clustered them to be more overseeable and easier to use. However, the limitation of the classification is that we only focused on industries, which are providing complex technical products, like plant manufacturing, machine tools, production machines, construction machines, energy and power. This classification is not applicable for other industries. Furthermore, this classification has a temporal limitation. As other services might appear in the future, they should be integrated in this classification. It might be helpful for PSS-providers to build an analogue service classification for the own company including services from the same sector. Since we described the procedure, how we built the classification, companies are able to use this procedure for building a company-specific classification. Another limitation of this classification is that the usage of it might restrict the creativity in designing new services. Applying this classification means to identify already existing services and makes it impossible to design services with a high level of innovativeness. Even though practitioners might not find innovative services using our classification, the number of 265 services makes it probable that creativity is not necessarily beneficial in some real cases. There is no clean proof that applying creativity will find services, which are not included in our classification. However, to find an answer to this question, if more creative ways to find services are more helpful, we have to test it in industrial cases, which we have not done yet.

ACKNOWLEDGMENT

We thank the German Research Foundation (Deutsche Forschungsgemeinschaft – DFG) for funding this project as part of the collaborative research centre 'Sonderforschungs-bereich' 768 – Managing cycles in innovation process – Integrated development of product-service systems based on technical products'.

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