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## How to design and evaluate early PSS concepts: the Product Service Concept Tree

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### Abstract

Recently, lots of manufacturing companies have been attracted by the possibility to differentiate themselves from competitors introducing product related services in their traditional portfolio. During this transition, however, companies are not properly supported by proper methods and tools. In particular, the majority of the approaches addressing the PSS design are limiting their field of application only to “service design” and are specifically focusing on requirements generation and identification phases of the design process. Few of the approaches analysed contribute to concept development and evaluation phases and if so, they just address one of the two phases. Therefore, the aim of this paper is to propose the Product-Service Concept Tree (PSCT) method. This aims at suggesting a possible structure to identify, collect possible PSS solutions and manage their assessment (i.e. the selection of the best PSS to implement). Furthermore, it includes guidelines to lead industrial practitioners in easily use it. An application of the proposed method is also presented to demonstrate its industrial applicability.

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### 1. Introduction

Recently, lots of manufacturing companies have been attracted by the possibility to differentiate themselves from competitors introducing product related services in their traditional portfolio. This transition from a product-based to a service-based business model, defined as servitization of business [1], might allow companies in the shift toward a better competitive position with regard to their competitors. However, it is well documented that this transition toward an enlarged value proposition can reach the expected optimum payback only if supported by proper tools and methods for the design, the implementation and the management of the new solution [2]. Therefore, the evolution toward a service-based business model creates a strong need for methods and tools to develop, handle and support decision making about the new portfolio. Indeed, when product offer is enlarged or integrated with services (i.e. Product-Service Systems- PSS) [3] all the product development phases need to be adapted to the more

complex offer scheme of PSS considering product, service, network and infrastructure.

Consequently, in the last years, numbers of researches have worked on the development of methodologies to support companies in the design of such integrated solutions [4,5,6,7,8,9]. This task is extremely complex due to the fact that “service design” has to be seamless integrated with traditional product design. Indeed, service design is characterized by high levels of intangibility, uncertainty and simultaneity (service is exploited when the provider and the receivers are simultaneously available) [10] that are difficult be managed together with traditional product design methods. As a results, the methodologies developed in the last decade lack a common vision, scope and structure. This is due to two main issues. First, the majority of the approaches addressing the PSS design are limiting their field of application to the enlargement of the traditional engineering approaches with “service design” approaches specifically facing service features (intangibility and simultaneity) and customer satisfaction.

Second, existing approaches are mainly focusing on specific phases of the design process leaving some issues still unsolved. In particular, as highlighted in [11] the majority of existing methods are focused on the requirements analysis specifically on their generation and identification. Very few approaches contribute to concept development and the related evaluation phases.

Therefore, in order to contribute to PSS design, this paper proposes a possible approach to guide both the PSS concept generation and evaluation phases. The approach proposed is intended to (i) integrate product and service enabling features design with the goal of designing PSS solution(s) capable of fulfilling customer(s) declared and latent needs and (ii) have a strong industrial orientation

Accordingly, this paper is structured as follows. Section 2 summarizes literature around PSS concept design and assessment, section 3 presents and describes the methodology in detail. Section 4 presents an application in the industrial environment of the PSCT and Section 5 closes the paper summarizing the main findings and future research directions.

## 2. Background and literature

As a general input to develop and design the method suggested, a review of literature was carried out. It aimed at reviewing existing methods in the area of PSS in order to shed the light on possible areas where to contextualize the current contribution. From now on, the authors will refer to a PSS design methods as the particular procedures for accomplishing or approach the objective of each PSS design phase (method definition by Oxford dictionary).

The literature analysis has been carried out inside different domains related to products, services and PSS in order to ensure content validity of the work. Among them, service engineering [12,13], value engineering [14] and design thinking [15] domains were analysed with narrow focus on the enhancement in PSS research field. As a starting point, up-to-date literature reviews on PSS Engineering and Design [4,5,6,7,8,9,16,11,17,18] have been used to have an overall understanding on the most well-known methodologies and the most adopted methods. Then, the research has been refined considering the mentioned works and other relevant issues related to concept design and evaluation. Recent journal papers and well cited conference or old papers have been included in the analysis.

Even if starting from 2008 research on PSS has increased [17], many of the methods adopted in the PSS field derive from traditional engineering and then they have been adapted to the features of PSS [11]. Only a small number of methods have been developed specifically for PSS design, development and engineering. Thanks to the analysis of [11], the most acknowledged methods in the PSS engineering field were identified. However, very few (or none) of them refers to the concept generation and the related evaluation phase. The reason behind this is mainly due to the intangible nature of services [19] and PSS solutions that make complex the formalization of the design phase. Further research in the area of service design leads to the identification of other existing work suggesting possible path toward PSS early design. Among the most adopted methods identified, the authors focus their attention on those contributing on the one side to concept

generation phase and on the other side to the evaluation of preliminary design concept.

### 2.1. Concept generation methods

Traditionally, the concept generation phase cannot be associated to a specific method. Each company has its own approach, such as brainstorming, focus group etc. that are far from an engineering perspective.

The literature carried out concerning concept generation methods highlighted some useful methods that can be used as useful guidelines to come out with possible design concept. TRIZ, for example, can be exploited to identify, generate and evaluate possible solutions to service problems in the engineering process [20] and to support the shift from “intuition” to “formal development” [21].

Additional suggestions are less structured and more focused on the innovative approach to identify the solution. For example, design thinking and service design thinking [22, 15, 23] emerged as a fuzzy discipline suggesting possible ways to think out of the scheme and generate ideas and PSS concepts. Among the approaches suggested by design thinking, graphic design, interaction design and social design are suggested but no one of them presents an engineering approach to formalize the findings and to evaluate the identified solutions. Indeed, they are mainly used to generate innovative and “out of the scheme” ideas, by providing only general guidelines. In the service design thinking the main guidelines are: i) it is user centred, ii) it is co-creative, iii) it is sequencing, iv) it is evidencing and v) it is holistic.

Other means to concept design are contained in [24] who suggest a possible approach to design a proper value proposition capable of fulfilling customer needs and of answering to customer requirements. The approach proposed by [24] suggests to design the profile of a customer and to define a possible value proposition. This approach does not follow an engineering method but is easy to be understood in the industrial context given its graphical appeal.

In addition to these streams, in service and PSS fields, some scholars propose their own approach to concept generation but they are far from the clarity and the immediateness of design thinking and business model canvas popularity. [25] focused on the design of experience-centric services, specifically referring to the design of service context. They developed a theory-based set of propositions that could provide guidelines to improve customer experience. The design of experience-centric services involves designing a series of service encounters and cues. [26] aimed at supporting service design defining four possible intelligence generation strategies to increase customer value but they do not really suggest how to design these strategies. [27] proposed a 4 step approach to PSS design. In step 2 they propose the definition of the PSS’s specification (i.e. concept generation) together with its evaluation considering the value (ratio between performances of some functions over their costs).

### 2.2. Concept evaluation methods

The literature scenario concerning the evaluation phase is wider since both quantitative and qualitative methods are available. On the one hand some scholars evaluate design concepts just considering the possible match between

customers' requirements and the identified value proposition [18], on the other hand some rigorous methods are used to determine the value of a solution according to formal categorization of interdependencies.

On the first category, [24] assess different value propositions according to their fit to customer requirements and needs. ServQual [28] has also been used to evaluate a concept according to the possible perception of outcome by the customer. [27] proposed the assessment of a solution considering its value as intended in value engineering: the ration between performance of some functions over their costs. In other cases the evaluation is carried out in a more meticulous way. ANP and AHP [29, 30, 31] have been used for the definition of the importance and the interrelations among different value criteria and customer experience cycle focusing on the evaluation of concepts. Pairwise comparison method has been also adopted to give prioritization to different dimension of value [29].

As a first conclusion based on the literature showed here, it is possible to underline that a shared and common approach to concept generation and evaluation is still missing. Some methods (ANP and AHP) are more common and robust while others are more qualitative. Furthermore, all the methods identified, apart from [27] are not connected to any technique for concept generation and vice-versa. In the next paragraph a possible method to overcome such gap is proposed. It suggests an easy and industrial-oriented way to generate and evaluate PSS concepts in the early phase of design considering both service and product design features.

**3. Product Service Concept Tree (PSCT) structure**

Considering the gap in literature highlighted in section 2 and the practical issue about PSS methods and tools in industry (hinted in section 1), this section aims at proposing the Product-Service Concept Tree (PSCT). This method aims at suggesting a possible way to i) identify PSS solutions capable of fulfilling customers' needs, ii) to represent solutions in a structured approach and finally iii) to manage the selection of the "best" PSS to implement. Furthermore, it includes guidelines to lead industrial practitioners to easily use it.

Indeed, to make it industrial-oriented, it has been developed in tight relationship with industrial environment through an iterative approach. Its final shape, presented in this paper, is the result of number of applications in industry. At the beginning, the approach was organized as a functional analysis implying the identification of product and service functions as an intermediate step to identify valuable PSS solutions. Once applied in industry, however, such a structured approach did not bring the expected results since practitioners without an academic background find some difficulties in understanding the concept of functionality, especially service one. Five applications in different companies were carried out and they allowed the identification of the improvements. The method in its final setting is the outcome of all the applications and represents the easiest approach that the authors find to make the method applicable and usable in everyday business.

It is organized in 4 main levels according to the elements described hereafter. The structure of the PSCT is represented in figure 1.

- Needs: Elements that customers consider essential or desirable.

- Wishes: How customers' wish to satisfy their needs
- Solutions: Possible solutions (product, services or a bundle of them) that the company can identify to fulfil customers' wishes and needs
- Resources: What are the main human/software resources and/or products and related features necessary to implement a solution

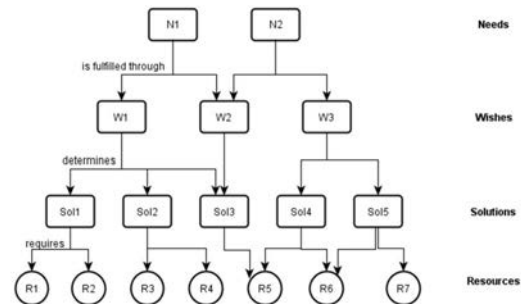


Figure 1: PS Concept Tree (PSCT) Structure

**3.1. Needs and wishes gathering**

The first phase of the PSCT is the identification of customers' needs and wishes. It can be done in three different ways according to the company business/market and considering data availability. Option 1 would be more suitable in a B2C context where customer opinions about the company are spread around social networks whereas option 2 would guide the work in the case of B2B company where direct information about products/services and customer satisfaction cannot be collected through social but a deep marketing analysis can be carried out. The last option is implemented when there are no data available or no time to collect data, for this reason brainstorming and focus group can be adopted. Here is a brief description of the three options.

1. Conduct a social network and sentiment analysis to collect a large amount of customers' opinion [32]. This analysis aims at summarizing opinions from social network in one single feedback (the expressed opinion from a post and its accompanying comments) and at aggregating those from different authors and sources during a time interval, to provide a global sentiment towards a company product/service. These social network and sentiment analyses would also provide information regarding polarity of opinions, but also on other aspects that affect the diffusion and the prevalence of them, such as influence, reach, ambiguity and relevance. Therefore, the global sentiment would be the result of a weighted evaluation of these aspects and it is used both for estimating current sentiment towards an object and for predicting future trends in sentiment. This would shed the light on existing customers' needs and wishes. More details about the way in which this analysis could be carried out are described in the DIVERSITY project [33].
2. In the case in which data gathering from social network is not available (i.e. the company does not have social network interaction with its customers), another way to identify needs and wishes in a structured way is based on the adoption of Persona model as proposed by [34].

According to the customers' features identified in [34] in the PSCT guidelines to deploy the concept tree levels and to identify a solution satisfying the "Persona" are reported. This provides specific and concrete representations of target users, based on real inputs and formally structured.

3. The last option, even if it is the less structured, is the easiest to be implemented since no data are required. PSCT needs and related wishes are identified "manually" through traditional brainstorming or focus group.

To properly support companies in identifying needs and wishes supporting the identification of new PSS, hints supporting the brainstorming process are included in the PSCT. In case of options 1 or 2, when quantitative data are available, the hints will support the formalization of the information obtained, in case of option 3 the hints will also drive the identification of needs and wishes.

For each level of the tree hints are created and reported in the followings:

#### 1. Describe the customer. [34]

- Consider their characteristics (type of business, market, volumes).
- Analyze the environment where they work (industry, competitors, substitute products /services).

#### 2. Identify customer's needs [34] [35]

- Try to understand what your customers need: is it different from what they are asking to your company?
- Think about different kinds of needs: needs that are related to a product/service function, needs to satisfy social goals, needs to fulfill emotions, etc.

#### 3. Identify customers' wishes

- Which are the wishes of your customer in relation to your business (i.e. what the customer is requiring to your company? How customers want to satisfy the previous identified need?)
- Consider the problems that your customer are expressing.
- Consider what your competitors are doing for your customers; may your customers require the same services to you?

### 3.2. Concept generation

The aim of this phase is to identify new PSS(s) that can answer to customers' latent or declared needs and wishes and identifying the resources required to deliver the product-service. The customers' needs and wishes identified in the first phase (either through social network, persona model or brainstorming) will be used as input. The output of this phase is a high-valuable PSS concept.

Since, by nature the brainstorming phase cannot be entrapped in a rigid structure, it is up to the designers or design team to think about a possible concept idea(s) and suggests solutions. There exist different approaches to be creative and to generate good ideas, as underlined in the literature review. The PSCT method does not strictly require the application of one of them but, in the concept generation phase, it provides a list of good practices and hints to support the brainstorming phase and summarization of ideas.

Since companies at the end of a brainstorming session needs to formalize their ideas, the PSCT supports the formalization of the results by graphically connect the needs, considered as

inputs, to the solutions identified (output).

Some of the hints suggested are presented hereafter. They refer to the major internal elements of a PSS plus an external component that in an industrial context cannot be neglected, namely the competitors. Guidelines are reported hereafter:

#### • Product features

- Do you think that your existing product(s) can have additional feature that can help in satisfying identified needs?
- Can you mix features of existing product(s) to satisfy identified needs?

#### • Service features [1]

- Can you add additional services to your portfolio?
- Are there any new possible services to satisfy the needs?

#### • Entire solution [36]

- Can you think at different combination(s) of product and services that can support such needs?
- Can you think additional way of selling the solution?

#### • Competitors offering [37]

- What are your competitors offering to customers? Does it worth to do the same?
- How can existing competitors' solution be improved?

### 3.3. Concept evaluation

In order to avoid late rework and revision in the development process, a first evaluation of the identified PSS concepts (or solutions) should be performed. The solution(s) identified through the PSCT previously developed should be evaluated, in order to pick up the one(s) that is worth to be implemented. The PSCT concept relies on an easy and intuitive approach. It considers i) the possible impact that the implementation of a solution can have on the company value and ii) the difficulty that the company could encounter during the implementation. The two factors are evaluated through a Likert scale from 1 to 5. Concerning the possible impact on the company business, a score of 1 refers to low impact while a score of 5 imply a big change in the company that can be in terms of market increase, innovations, and technology or process optimization. Difficulty in the implementation refers to the effort that the company encounter during the implementation of a solution. A score of 5 means that the company need a deep change in the organization or a high investment in order to implement this change.

Once assigned "impact" and "difficulty" scores the preferred solution can be selected. Reasonably, the first one to be implemented should be the one which requires lower effort (limited difficulty) and produces the higher impact.

Such an elementary evaluation method has been selected considering the stage of the design. In the PSCT phase the concepts are still in their early development phase and a detailed evaluation about costs, resources and market for each solution won't be feasible. Furthermore, as the entire PSCT method, this evaluation step is designed to be easily understood also by people without academic background.

The method applicability to industry will be demonstrated in the next paragraph that describe the application of the proposed method to a real case in collaboration with one company that from now on will be mentioned as Company A.

#### 4. Test of the PSCT in a real case

The PSCT approach has been validated in a real industrial case (company A). The application was structured as a brainstorming meeting dedicated to PSS concept generation and validation. The brainstorming was led by the PSCT structure presented by academic people from the DIVERSITY project. People from different company function were involved during the application. Such roles heterogeneity has been considered as a key point to collect contributions on different perspectives. In particular, the participants to the PSCT validation were: one marketing employee, one customer contact and claim employee, one working on product management (between R&D and marketing), two from Lean operations office. All the people were asked to contribute to the discussion and to feel free to suggest any kind of idea. Then, each step of the PSCT was performed. Since the company works in a B2B environment it cannot gather customer's needs from social network. Furthermore, no structured market analysis were available so the first two levels of the tree were completed "manually" (3<sup>rd</sup> option presented before). Hereafter, a brief description of each step of the tree development is reported.

**1. Identification of customers' segment.** One customer segment was selected as the focus of the work: Customers owning a water treatment system. These customers buy the water treatment system in order to ensure a continuous functioning of their humidification systems. They usually buy the product from Company A, then pay a third party supplier for the installation and commissioning. In Italy, Company A can rely on a certified network of expert in other countries the company doesn't have this kind of structure.

**2. Description of customers.** As in all steps, the hints previously presented, support description of the customer segment under analysis. Referring to a real customer segment this phase is useful to highlight the customer's features considering different perspectives. Many characteristics emerged during the discussion, it is worth to highlight that these customers are a small part of company business. The customers buy a highly customized product and specific needs are satisfied only during the initial commissioning.

**3. Identification of customers' needs.** The customer main needs can be summarized in *i) continuous functioning of the product* and *ii) long life cycle*. This is mainly because customer does not want to care about this product which covers a support function in the plant organization.

**4. Identify customer's wishes.** The description of customers and of the issues that customers have to face when dealing with Company A, emerged in step 2, favoured the definition of wishes. They are *i) good installation and commissioning*, *ii) good maintenance* and *iii) ease of use*. All of these are possible ways in which customer can achieve proper functioning.

**5. Identify possible solutions.** By following the PSCT structure and hints, the heterogeneous group participating in the brainstorming contribute to the recognition of possible solutions. According to the PSCT hints, participants were lead to shed the light on company strengths and weaknesses with respect to external actors. This awareness allows the statement of possible solutions that can bring the company to the same

level as competitors. In the specific case, the company doesn't have competitors acting globally as the company itself. Competitors are usually local companies which can follow the customer throughout the entire product lifecycle, therefore they can be preferred to Company A for the direct support they can provide to customers. On the other hand, Company A has a competitive advantage based on technology. Accordingly, one of the solutions emerged through the PSCT is the *increase of field service network in foreign countries*. Associated to this issue, another solution emerged. It was highlighted that commissioning is a key aspect for the proper functioning of the machine but in the majority of cases it is not properly performed because of the lack of knowhow about products. Possible solutions identified to solve it are: *Easy manual (or instruction)*, *automatic installation and commissioning* and *poka-yoke embedded in the machine*. Additional solutions emerged related to the monitoring of the customer behaviour during the product lifecycle. Among them: *better knowledge of the final customer*, *maintenance intervention traceability*, *remote monitoring of the machine* and *an APP based on augmented reality to guide customer during maintenance*.

**6. Identify the required resources.** In this step, the resources, in terms of product features and activities required to deliver or implement the service, are linked to all the solutions identified. For example, for the *increase of service in foreign countries*, a change in company organization and the hiring of additional employee around the world are needed. In the case of *poka-yoke embedded in the machine*, product features (such as sensors) are needed; the organization and the service activities won't be affected. The definition of resources, performed for each solution, allows the identification of the effort required during implementation.

**7. Solutions evaluation and selection.** The last step proposed by the identified method is the evaluation of the solution proposed. According to the PSCT, each solution was associated to two different grades (from 1 to 5) to evaluate *i) the effort required to implement such a solution* and *ii) the impact that the solution can have on everyday business*. The grades assigned during the test are the following.

Table 1 PSS concept evaluation in Company A

Solution	Effort	Impact
Increase of service in foreign countries	5	4
Easy manual (or instruction)	1	2
Automatic installation and commissioning	4	5
Poka-yoke embedded in the machine	4	5
Better knowledge of the final customer	4	1
Maintenance intervention traceability	2	2
Remote monitoring of the machine	3	3
APP based on augmented reality	2	3

The final solution selected is the one with lower effort to be implemented and higher impact: *APP based on augmented reality*. The final results of the PSCT application revealed a good applicability of the identified approach. Each phase has

been properly supported by the guidelines proposed and by the tree interface of the PSCT. Furthermore, industrial people provide good feedbacks about the steps suggested by the PSCT and about the industrial applicability of the method.

## 5. Conclusions and further development

Literature review among existing PSS design methodologies shed the light on the lack of methods and tools to lead the PSS concept definition and evaluation. In this paper, the authors propose a former draft to support these phases through the PSCT. This method, similar to the traditional functional analysis adopted for product development, is organized in 4 levels reflecting i) customers' needs ii) wishes (how a customer wishes to satisfy its needs) iii) PSS concepts solutions and iv) resources required to implement that solution. Then, the PSCT supports a first evaluation of the solutions.

So far, the PSCT is in its early development phase and a first application in a real case revealed a good applicability of it in an industrial context. However, it needs to be applied in several industrial cases to additionally evaluate its effectiveness in supporting everyday business. Further analysis will be related to the evaluation phase. Additional research for existing methods adopted in the concept evaluation phase will be carried out, they will be then compared and tested to select the most suitable and complete to be used in the PSCT. Other improvements of such methodology could be related to the integration of the PSCT with existing methods for PSS design and implementation. This would support companies in offering the PSS concept identified through the PSCT.

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