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Development of a novel set of criteria to select methodology for designing product service systems

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Abstract

This paper proposes eight groups of twenty nine scoring criteria that can help designers and practitioners to compare and select an appropriate methodology for a certain problem in designing product service system (PSS). PSS has been researched for more than a decade and is now becoming more and more popular in academia as well as industry. Despite that fact, the adoption of PSS is still limited for its potential. One of the main reasons is that designing PSS itself is a challenge. Designers and developers face difficulties in choosing appropriate PSS design methodologies for their projects so that they can design effective PSS offerings. By proposing eight groups of twenty nine scoring criteria, this paper enables a "step by step" process to identify the most appropriate design methodology for a company's PSS problem. An example is also introduced to illustrate the use of the proposed scoring criteria and provide a clear picture of how different design methodologies can be utilized at their best in terms of application.

Keywords: Product service system; PSS; PSS application; PSS design methodology selection

1. Introduction

1.1. Product service system

Product service system (PSS) forms a special case in servitization [36] where a company provides its customers with an offering including physical product and non-physical service. This new concept of providing PSS offering is different from selling product only which is becoming more and more difficult to compete, especially in today's scenario of economic crisis, growing environmental issues and diversified customer demands [37,5,36]. As mentioned in literature, the introduction of PSS can help companies to enhance competitiveness, achieve social, environmental, and economic goals, as well as attract and retain customers [7,28,27,8].

Formally, PSS is defined by many authors, including Goedkoop et al. [10]. In this work, PSS was defined as "a marketable set of products and services capable of jointly fulfilling a user's needs. The product/service ratio in this set can vary, either in terms of function fulfillment or economic value". This definition makes the concept of PSS close to functional economy [22] where customers pay for the "function" or the "use" of the solutions, not for the physical products. PSS concept also matches with the thinking of "hiring products to get jobs done" which was mentioned by Bettencourt and Ulwick [7] and was further discussed by Lim et al. [17] and Hussain et al. [12].

Some researchers suggested that PSS could be considered as an integrated system which consists of products, services, and the infrastructure to deliver a solution to a customer to satisfy certain needs [28,27,36]. An example of PSS is the "document management solution" which is discussed in the work of Baines et al. [6]. Conventionally, a customer would buy a physical product which is a photocopier. With the "PSS model", the customer will only "buy" the capability of

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document management and leave the rest of the work (refill, maintenance, replace parts, etc.) to the manufacturer.

Early works on PSS related topics were carried out more than a decade ago with pioneer researchers such as: Goedkoop et al. [10], Mont [22] and Morelli [24]. As summarized by Vasantha et al. [36], research on PSS has ranged from the definition of PSS elements, generation of PSS offerings, representation of PSS, etc. to the evaluation of PSS offerings, sustainable development, design process for integrating products and services etc.

Tukker [34] classified PSS into 3 types as follows:

- Product oriented PSS: Company sells a product with additional services to ensure the working condition of the product. The ownership of the product is transferred to the customer. Services such as: maintenance, repair, recycling, refilling, etc. could be classified into this type.
- Use oriented PSS: Company sells the use or availability of a product not owned by the customer. Examples of this type are product leasing or sharing.
- Result oriented PSS: Company sells a result or capability of a product not owned by the customer. For example, instead of selling paint to a customer, the company can sell the result, a painted house.

1.2. Benefits of PSS and challenges for adoption of PSS in industry

Surveys by Baines et al. [6] and Beuren et al. [8] showed the benefits of PSS to the consumer, provider, environment and society. These benefits result from the higher level of satisfaction, increased competitiveness, decreased environmental impact and materials savings. The main benefit of PSS for the company is that it pushes for continuous business improvement, quality improvement, and better company–customer relationship. Table 1, which is adapted from Beuren et al. [8], shows how the PSS benefits the consumer, provider, environment and society. In this sense, PSS is closely related to sustainable development and green technology.

Although PSS brings plenty of benefits, it is still adopted limitedly in the industry for its potentials. The major challenges in adopting PSS were suggested by Mont [22], Baines et al. [6] and Beuren et al. [8]: first, consumers may not be enthusiastic about ownerless consumption; second, the manufacturer may be concerned with pricing, absorbing risks and shifting organization; and third, PSS design and development itself is a challenge. PSS is difficult to design because it is an integrated system consisting of products, services, and delivery infrastructure, and is strongly affected by stakeholders. Designers and developers need an appropriate design methodology to deal with each design project. There are several design methodologies available in literature but none of them is holistic to work with a wide range of PSS problems and there is a lack of analysis and guidance of possible applications for each methodology.

Table 1
Benefits of product service systems

PSS benefits
Consumer
Flexible and personalized service; quality and satisfaction; Continuous improvement of products and services
Provider
Customer loyalty and trust; Innovation by monitoring products in use Cost and resources reduction; maximization of results; knowledge created during the development process are sold as consulting and training services; products reused in combination with several different services
Environment
Reduction in consumption through alternative use of product; Provider's responsible for the products and services through take-back, recycling, and refurbishment-reducing waste throughout the product's life; services planned according to the life cycle of the product
Society
Public pressure on environmental issues grows; Increase in the supply of services; new jobs

2. Literature review

Many methodologies for designing PSS are presented in the literature [36,17,8]. Some methodologies are case-specific, meaning that they are tailored for specific projects, including the ones proposed by Luiten et al. [18], Manzini and Vezolli [19], and Morelli [23,24], etc. These are not generic for a broad range of cases.

Other methodologies are suitable for designing of a broad range of PSSs. Vasantha et al. [36] summarized eight methodologies in the literature that have been detailed, applied, and demonstrated with industrial examples. These methodologies can be applied in complex PSS development influenced by many factors. Table 2 provides the brief description of those eight methodologies. Details of eight methodologies are provided in the work of Vasantha et al. [36].

Vasantha et al. [36] also pointed out major limitations of these PSS design methodologies due to which, none of the methodologies can solve PSS design problems comprehensively. Selection of appropriate methodology for a specific PSS problem is an essential part of PSS implementation. Designers and practitioners need tools and guidelines that can support the selection of the most appropriate methodology for their PSS design problems. One of the well known generic selection tools which is called Decision Matrix can be found in literature [35]. This tool supports the selection of the most appropriate item out of a "collection" through comparing items with one another by scoring them along various criteria with various levels of priority. So far, none of such scoring criteria is available.

By analyzing existing literature on PSS design and development with regards of the perspective of practitioners, this paper aims to propose a new set of scoring criteria which enables a step by step selection process of the most appropriate design methodology using Decision Matrix. This supports

Table 2
Eight methodologies which were reviewed by Vasantha et al. [36], The bold names in parentheses represent nomenclatures of methodologies in this paper.

Method	**Description**
Service CAD (**Service CAD**)	A method to design business models that increase eco-efficiency from a systemic perspective. [33,14–16]
Service model Service explorer (**Service explorer**)	Focuses on service engineering to design products with a higher added-value from enhanced services. Sakao and Shimomura [26]; Shimomura et al. [30,29]; Sakao et al. [28,27]; Kimita et al. [13]; Hara et al. [11].
Integrated product and service design processes (**Integrated PSD**)	Exploits the potential of interrelations between physical products and non-physical services and the development of corresponding design processes. Aurich et al. [3,4].
Fast-track total care design process(**FTTC**)	Develops innovative offerings consisting of hardware and services integrated to provide complete functional performance. Alonso-Rasgado et al. [1,2]
PSS design (**PSS design**)	Assists engineers in the joint development of physical products and interacting services to generate more added value. Maussang et al. [20].
Heterogeneous IPS^2 concept Modeling (**IPS^2**)	A model based approach of diffuse borders between products and services that generates heterogeneous Industrial Product-Service Systems (IPS^2) concept models in the early phase of IPS^2 development. [21,38,25].
The dimensions of PSS design (**Dimensions**)	A comprehensive description of PSSs capable of generating new PSS concepts. Tan et al. [31,32].
The design process for the development of an integrated solution (**Integrated solution**)	Development of methodological tools to support designers and generate systemic solutions including products and services. Morelli [23,24].

designers and practitioners to effectively deal with their own specific PSS problem and thus, this work provides an effective and quantitative tool to optimally use PSS design methodologies in various scenarios.

3. Methodology

3.1. Scoring criteria in comparing design methodologies

As discussed in Section 2, so far, there is no existing scoring criterion available to compare design methodologies. Without scoring criteria, the comparison among design methodologies would not be quantitatively precise and objective. Following analyses show how the authors propose scoring criteria. The names of groups of criteria and the grouping are proposed by the authors.

3.1.1. Group 1: holistic approach

Vasantha et al. [36] implied that there are differences among design methodologies for different types of PSS (i.e. product oriented PSS, use oriented PSS, and result oriented PSS). For example, a design methodology which is used effectively for product oriented PSS sometimes cannot be used for use oriented PSS. As a designer, one may concern whether a design methodology is appropriate for his PSS problem or not. When selecting a design methodology, this “holistic approach” becomes one factor which influences the designer’s decision. Therefore, there is a need of a group of scoring criteria which is named “holistic approach”. Scoring criteria of the group includes:

- usability for product oriented PSS,
- usability for use oriented PSS, and
- usability for result oriented PSS.

3.1.2. Group 2: practical approach

As pointed out by Baines et al. [6], Vasantha et al. [36], and Cavalieri and Pezzotta [9], one thing that limits the adoption of PSS to industry is the lack of practical approach of design methodologies. Some among the existing design methodologies do not include the “how” in their design process meaning that they do not show the designers how to use the methodology in actual cases in a step-by-step manner which is highly interested by designers and practitioners. In some methodologies, the presence of a clear process flow is missing. For most of methodologies, detailed design activities through the design process and design checkpoints which are critical factors for practical application are also not available. When selecting a design methodology, a designer may concern whether the design methodology is “practical” or not and therefore, there is a need of a group of scoring criteria which is named “practical approach”. If a design methodology is practical, it can provide a step by step design process which can help designing PSS effectively. Scoring criteria of the group includes:

- availability of process flow,
- availability of design activities through the flow,
- availability of design checkpoints, and
- availability of product–service integration details.

3.1.3. Group 3: co-creative approach

Luiten et al. [18] implied that one important factor that leads to the successful implementation of a PSS design methodology is the consideration of co-creation of users in the design process. If a design methodology is co-creative, it can promote user involvement during the design process and thus enhance the outcome. But for most of existing design methodologies, the co-creation factors are missing. There is a lack of detailed description about stakeholders' roles and capabilities as well as the details of where to take into account user involvement. To precisely select a design methodology as a designer, a group of scoring criteria named "co-creative approach" is necessary. Scoring criteria of the group includes:

- specification of stakeholders' roles and capabilities and
- detail of where to take into account user involvement

3.1.4. Group 4: systemic approach

Tomiyama [33], Mont [22], Morelli [23,24], Baines et al. [6], Komoto and Tomiyama [14,15], Komoto [16], and Vasantha et al. [36] mentioned that a PSS should be designed at systemic level meaning that all PSS elements such as: product, service, business model, organizational structure, delivery channel and stakeholder's presence are considered in the design process. This is because PSS is an integrated system of all the above elements. In order to select the right design methodology for a PSS problem, "systemic approach" becomes one important group of criteria. Scoring criteria of the group includes:

- coverage of business model,
- coverage of organizational structure,
- coverage of delivery channel,
- coverage of product and service, and
- coverage of stakeholder's presence.

3.1.5. Group 5: lifecycle approach

The approach of designing PSS through its lifecycle is important and has been stressed by Manzini and Vezolli [19], Meier and Massberg [21], Aurich et al. [3,4] and Baines et al. [6]. They commented that a PSS needs to be designed from the very first idea until the retirement. The design methodology needs to consider the phases such as: idea development, planning, requirement analysis, etc. in its design process. This is critical to the application of PSS nowadays. Therefore, there is a need for a group of scoring criteria named "Lifecycle approach" when a designer wants to select an appropriate design methodology. Scoring criteria of the group includes:

- coverage of idea development,
- coverage of PSS planning,
- coverage of requirement analysis,
- coverage of concept development,
- coverage of design and integration,
- coverage of testing and refinement,
- coverage of implementation and support
- coverage of retirement and recycling
- coverage of feedback loops
- coverage of sustainable design

3.1.6. Group 6: evaluable approach

Evaluation is one important issue in PSS design. Evaluation of a PSS before its official launching might help to decrease risk and uncertainty dramatically [36]. But for most of existing design methodologies, the "evaluation" aspect was not considerably developed, as mentioned by Baines et al. [6], Komoto [16] and Vasantha et al. [36]. If a design methodology is evaluable, meaning that it includes evaluation algorithms and/or testing results and/or a well structured design process, it can produce predictable and assessable outcome. Because of the importance of the evaluation aspect to the success of PSS design and implementation, for selecting the most appropriate design methodology for a PSS problem, a designer needs a group of scoring criteria named "Evaluable approach". Scoring criteria of the group includes:

- availability of algorithms for evaluation
- availability of testing and evaluation results with a case
- presence of well structured design process

3.1.7. Group 7: computer aided approach

If a design methodology is supported by a computer tool, it can accelerate the work of designers and developers. There are a few design methodologies which offer computer tools. "Computer aided approach" can be considered as another group of scoring criteria when selecting an appropriate design methodology. Scoring criteria of the group includes:

- availability of computer tool to assist design process

3.1.8. Group 8: proved approach

From the designers' perspective, there is a need for one more group of scoring criteria named "Proved approach". This group contains criteria that show the design methodology is proved to be applicable in real cases. If the result of a design methodology is proved, it can give designers and developers confidence to use. Scoring criteria of the group includes:

- availability of successful cases

Through the analysis above, we propose totally eight groups of twenty nine scoring criteria including Holistic approach, Practical approach, Co-creative approach, Systemic approach, Lifecycle approach, Evaluable approach, Computer aided approach and Proved approach. These criteria reflect almost all aspects that practitioners need from a design methodology. Using tools such as Decision Matrix, along these scoring criteria, the methodologies will be compared and the best methodology can be identified.

3.2. Application of the proposed scoring criteria to compare and select design methodologies

In this section, we propose an example framework which uses the proposed scoring criteria to select the most appropriate design methodology from a given group of existing design methodologies.

To compare design methodologies, we start with identifying the score that each methodology earns for each criterion. The scoring rules are adapted from Vasantha et al. [36]. If a criterion is not mentioned in a design methodology, we give it a score of "0". If an criterion is briefly mentioned (but is not discussed in detail) in a design methodology, we give it a score of "1". Finally, if a criterion is discussed in detail in a design methodology, we give it a score of "2". The total score that a methodology earns for a group of criteria is the total sum of scores that it earns for criteria in that group.

Each single PSS design project has its own characteristics and thus, for each project, designers and developers might have different priority levels for different features of a design methodology. These "features" are reflected by the proposed scoring criteria. To construct a process that can help designers and developers to select the most appropriate design methodology for their PSS problem, we hereby use Decision Matrix, a tool that is used to describe a multi-criteria decision analysis (MCDA) problem and was used in the domain of New Product Development to select the best product concept [35]. The steps of the selection of PSS design methodology are illustrated as follows (Fig. 1).

In this part, we use an example of a company to illustrate how the above selection process can be implemented. It is assumed that small company A needs to design a new PSS which is about leasing technical manuals and books together with supporting services (lectures, application workshops, technical contests, etc.). Their target customers are engineering individuals as well as small technical companies. This is niche market and their PSS is highly customized due to the diversified demands of various customers.

In order to design a new PSS, company A needs to use a design methodology. They decide to select one from the eight existing design methodologies (mentioned in Section 2) which are well known in literature [36]. Due to the characteristics of Company A and their PSS problem, they require the methodology to be:

- *Co-creative*: This is important since company A's PSS is customer intensive.
- *Evaluable*: This is important since company A is a small company, they need to minimize the risk before launching the PSS by evaluating the outcome.
- *Practical*: This is rather important since company A's employees are not PSS experts and they need a clear guideline to design PSS.
- *Computer aided*: This is rather important since the employees can be supported to simplify the design tasks.
- *Lifecycle*: This is required but somehow less important. Company A wants to manage the lifecycle of its product and services effectively.

The methodology does not need to be:

- *Holistic*: This is not required since company A is dealing with only one type of PSS.
- *Systemic*: This is not required since the PSS which is provided by company A does not require complex networks and infrastructure.
- *Proved*: This is not required since this leasing PSS is rather new in company A's market.

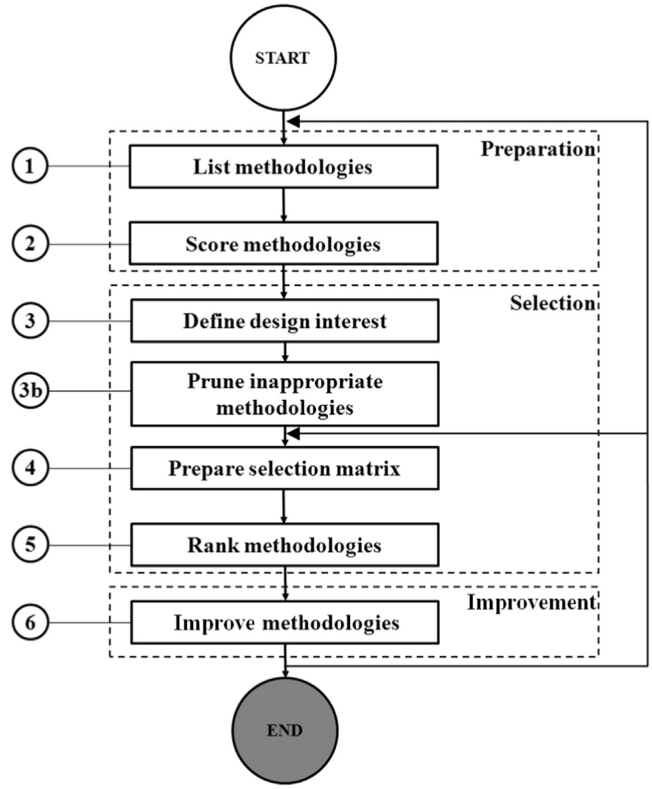

Fig. 1. Steps to select design methodology for a PSS problem.

The question is which one among the eight existing design methodologies is the most appropriate methodology for designing Company A's PSS problem. Using the proposed eight groups of scoring criteria, we implement the above process to this case. Details of the steps are as follows:

3.2.1. Preparation phase

- Step 1: Prepare a list of possible/available PSS design methodologies.

Implementation: We prepare a list of eight PSS design methodologies, which are: Service CAD, Service Explorer, Integrated PSD, FTTC, PSS Design, IPS2, Dimensions, and Integrated Solution.

- Step 2: Score methodologies along all scoring criteria.

Implementation: We score these eight methodologies with scoring rules mentioned in Section 3.2. The scoring results are shown in Table 3.

3.2.2. Selection phase

- Step 3: Define a list of scoring criteria of interest (for the PSS problem).

Table 3
Scoring result of eight methodologies.

Group	Scoring criterion	Service CAD	Service Explorer	Integrated PSD	FTTC	PSS Design	IPS^2	Dimensions	Integrated Solution
Holistic approach	*usability for product oriented PSS*	2	1	2	2	2	1	1	0
	usability for use oriented PSS	0	2	1	0	1	2	1	1
	usability for result oriented PSS	0	1	0	0	1	1	1	2
	Total score	**2**	**4**	**3**	**2**	**4**	**4**	**3**	**3**
Practical approach	*availability of process flow*	2	2	2	2	2	2	2	2
	availability of design activities through the flow	2	2	2	2	1	2	0	2
	availability of design checkpoints	2	2	0	0	0	2	0	2
	availability of product – service integration details	2	2	2	2	2	2	1	2
	Total score	**8**	**8**	**6**	**6**	**5**	**8**	**3**	**8**
Co-creative approach	*specification of stakeholders' roles and capabilities*	2	2	0	2	2	1	1	1
	detail of where to take into account user involvement	1	1	0	2	2	1	1	1
	Total score	**3**	**3**	**0**	**4**	**4**	**2**	**2**	**2**
Systemic approach	*coverage of business model*	1	1	0	2	1	1	2	2
	coverage of organizational structure	0	0	0	0	1	0	0	1
	coverage of delivery channel	1	2	1	1	1	2	1	1
	coverage of product and service	2	2	2	2	2	2	2	2
	coverage of stakeholder's presence	2	2	0	2	2	1	2	2
	Total score	**6**	**7**	**3**	**7**	**7**	**6**	**7**	**8**
Lifecycle approach	*coverage of idea development*	0	0	2	2	0	2	2	0
	coverage of PSS planning	0	0	2	2	0	2	2	2
	coverage of requirement analysis	0	2	2	2	2	2	2	2
	coverage of concept development	0	2	2	2	2	2	2	2
	coverage of design and integration	2	2	2	2	2	2	1	2
	coverage of testing and refinement	2	0	2	2	0	2	2	2
	coverage of implementation and support	0	0	0	0	0	2	0	0
	coverage of retirement and recycling	0	0	0	0	0	0	0	0
	coverage of feedback loops	2	0	0	0	0	0	0	0
	coverage of sustainable design	0	0	0	0	1	0	0	0
	Total score	**6**	**6**	**12**	**12**	**7**	**14**	**11**	**10**
Evaluable approach	*availability of algorithms for evaluation*	2	0	0	1	0	0	0	0
	availability of testing and evaluation results with a case	2	0	0	0	0	0	0	0
	presence of well structured design process	2	2	2	2	2	2	0	2
	Total score	**6**	**2**	**2**	**3**	**2**	**2**	**0**	**2**
Computer aided	*availability of computer tool to assist design process*	2	2	0	0	0	0	0	0
	Total score	**2**	**2**	**0**	**0**	**0**	**0**	**0**	**0**
Proved approach	*availability of successful cases*	0	2	2	0	2	2	0	2
	Total score	**0**	**2**	**2**	**0**	**2**	**2**	**0**	**2**

Table 4
Decision matrix for the selection of Company A

Scoring criterion	Methodology	Service CAD		Service Explorer		PSS Design	
	Importance (%)	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
Holistic approach	0	2	0	4	0	4	0
Practical approach	15	8	1.2	8	1.2	5	0.75
Co-creative approach	30	3	0.9	3	0.9	4	1.2
Systemic approach	0	6	0	7	0	7	0
Lifecycle approach	10	6	0.6	6	0.6	7	0.7
Evaluable approach	30	6	1.8	2	0.6	2	0.6
Computer aided approach	15	2	0.3	2	0.3	0	0
Proved approach	0	0	0	2	0	2	0
Final score		**4.8**		**3.6**		**3.25**	

Implementation: Due to the above analysis about requirements for the methodology, “Co-creative”, “Evaluable” need to be assigned with highest importance factor. “Practical” and “Computer aided” need to be assigned with the second highest importance factor. “Lifecycle” needs to be assigned with a medium importance factor. After the discussion among Company A’s design team members, the assignment of importance factors to criteria is shown in Table 4.

- Step 3b: Prune methodologies which are obviously inappropriate. Prioritize each scoring criterion with an importance factor (i.e. weight) according to PSS problem’s characteristics.

Implementation: From the scoring result in Table 3, we see that five methodologies, which are: Integrated PSD, FTTC, IPS2, Dimensions and Integrated Solutions can be pruned from the list because they gain the lowest scores for being “co-creative”, “evaluable” and “computer aided”.

- Step 4: Prepare the decision matrix and calculate final score each methodology earns (considering importance of each scoring criterion).

Implementation: According to the scoring result in Step 2, the definition of design interests in Step 3 and the pruning or inappropriate methodologies in Step 3b, Company A’s design team assign importance factors for design scoring criteria and prepare the decision matrix as shown in Table 4.

- Step 5: Specify the highest scored design methodology

Implementation: We calculate weighted scores for 3 methodologies which are: Service CAD, Service Explorer and PSS Design and the results are shown on Table 4. According to Table 4, for Company A’s design interests, Service CAD which gains the highest final score of 4.8 appears to be the most appropriate methodology. Service CAD will be the selected methodology for Company A’s design problem.

3.2.3. Improvement phase

- Step 6: Consider low scored design methodologies to utilize their “high performance” criteria and try to implement those “positive points” into the highest scored design methodology in Step 5 or try to implement those positive points into other design methodologies to form new methodologies and repeat the selection process from Step 1.

Implementation: From Table 4, we see that, the methodology named “PSS Design” performs the best for “co-creative”. Company A might want to try to implement this positive point of “PSS Design” methodology to the selected methodology (i. e. Service CAD) to form a more effective methodology. For a comparison in a higher level of details, company A can put any criterion among 29 criteria in the decision matrix.

4. Discussions

By applying the proposed scoring criteria and the comparison scheme, through a step by step process, company A can effectively and quantitatively identify the most appropriate design methodology for their specific PSS problem. In general, any company can apply this approach to any collection of design methodologies to indentify which methodology is the most appropriate for a certain PSS design problem. The comparison result of eight methodologies shows that for company A’s PSS problem, the most appropriate methodology is “Service CAD”. If company A uses a randomly “trial and error” selection tactic, the possibility of choosing the inappropriate methodology will be 87.5% (i.e. 7/8).

The main contribution of this paper is the proposal of eight groups with twenty nine scoring criteria along which the methodologies can be scored, compared and the most appropriate methodology for a certain PSS problem can be identified. These scoring criteria are the enabling factors for the selection of PSS design methodologies.

In the future, there will be more and more PSS design methodologies proposed and these criteria can be applied to support designers to select the most appropriate design methodology from any set of design methodologies. Also, this paper introduces the use of Decision Matrix as a tool for the selection of PSS design methodologies which are different from product concepts in the conventional situation.

The main advantage of the proposed criteria is the ability to assist designers to compare PSS design methodologies along various aspects and thus, the comparison result is comprehensive and significant. In this sense, the criteria act as requirements for a methodology which is under consideration. Therefore, the selection process focuses on the "needs" of designers and produces precise result (i.e. selection).

There are certain limitations for the appoach in this paper. The criteria are retrieved from analysis of existing literature. A survey of opinions from researchers and designers might be needed to ensure accuracy and adequacy. Also, there is a lack of method to assist designers to assign importance exactly in scoring step. There might be alternative methods to compare PSS design methodologies other than Decision Matrix. One of the possible methods is weighted Radar Chart in which weighted scores are used instead of raw scores. This weighted Radar Chart enhances visuality of the comparison result as well as enables rapid detection of possible improvements ("Improvement phase" – Step 6 in Section 3.2).

5. Conclusions

In this paper, the authors propose eight groups with twenty nine scoring criteria to enable a step by step process that can specifically help designers and practitioners to select appropriate design methodologies for their PSS problems. We also include an example in to illustrate how a company can use the proposed eight groups of scoring criteria and the comparison scheme to identify the most appropriate design methodology for its own specific PSS problem from a set of eight popular existing design methodologies. Future work might contain the topic of developing a new PSS design methodology which is "customizable" and "adaptive" so that it can transform itself to effectively solve a wide range of PSS design problems.

Conflict of interest

There is no conflict of interest for this work.

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