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A TOOL FOR CONCEPTUALISING IN PSS DEVELOPMENT

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1 Abstract

This paper introduces a tool for conceptualising in the development of product/service-systems (PSS), based upon the modelling of service activities. Our argumentation is built on two previous articles by the same author, previously presented at the 16. Symposium “Design for X” [1] and the 9th International Design Conference [2]. In this contribution, we take the step from a fundamental understanding of the phenomenon to creating a normative exploitation of this understanding for PSS concept development. The developed modelling technique is based on the Customer Activity Cycle (CAC) model by Vandermerwe [3]. Our subsequent development and tailoring of this model has been carried out in repeated applications (and evolution) via a number of projects conducted by Design & Innovation (D&I) engineering students at The Technical University of Denmark (DTU). The documentation of these projects, foremost a recent project in the shipbuilding industry [4], represent the main data source for this paper.

The resulting *Activity Modelling Cycle* (AMC) model has been refined and changed in order to address many of the issues identified as central for PSS development. The model has been found to support the integrated consideration of the customers’ activities, possible PSS offerings and beneficial partnering options (i.e. between different supplier companies) within the delivery value chain.

2 Introduction

The global society is gradually realising the need for optimised resource consumption, and is searching for solutions and business models that promise not only local optimisation but sustainable consumption from an overall perspective. In parallel, a general shift in focus from the exchange and consumption of goods to the exchange of competences and the consumption of services emerges. Within business environments more and more enterprises throughout the industrialised world focus their internal competences and operations, outsourcing all other operations and tasks to external suppliers or network partners. This outsourcing of activities implies that the partnering supplier companies perform an alignment and development of customised solutions to fit the needs of their contractors. But also private consumers are readily subscribing to a rising number of service offerings, requiring companies to change their operations and products accordingly.

Within the research community, servicing partnerships of this kind have been dubbed functional products as e.g. by Alonso-Rasgado et al. [5], functional sales as e.g. by Sundin and Bras [6] or product service systems as e.g. by Goedkoop et al. [7], Manzini and Vezzoli [8] or Mont [9] where each of the separate research groups have taken their own approach towards the phenomenon, focusing of different characteristics and types of what the authors of this contribution call product/service-systems (PSS). Generally the researchers have been driven by the opportunities of optimised resource consumption, which are identified as a major benefit inherent in PSS based business models. We believe that the opportunity of environmentally sustainable solution offers is just one of a number of possible benefits as described in [2].

2.1 Dimensions of PSS research

As the key issues presented in the referred papers indicate, the research in the area of PSS has a number of dimensions:

1. A theoretical understanding of the operations related opportunities inherent in PSS approaches to business, exploring and explaining opportunity parameters pointing towards e.g. the dematerialisation of offerings, optimising of performance or consumption etc. This dimension could also be referred to as *PSS as a potential of benefit.*
2. A theoretical understanding of the phenomenon of combined product and service offerings, exploring and explaining the inherent virtues and inferiorities of physical products throughout their life cycles and how these can be supported and relieved by service offerings. This dimension could also be referred to as *PSS as a theory.*
3. A prescription of the structures and management technologies necessary to enable companies and company networks to develop, deliver and operate PSS solutions. This dimension could also be referred to as *PSS as a strategy.*
4. A prescription of the processes which will enable development teams to identify and take advantage of the potentials referred to in paragraph 1 of this listing. Furthermore a prescription of working tasks and documentation models aiding the development team in the concretisation, communication and realisation of PSS solutions. This dimension could also be referred to as *PSS as development methods.*

2.2 Focus of this paper

In this paper a tool for conceptualising in the development of product/service-systems (PSS) is introduced, based upon the modelling of servicing activities. Our argumentation is built on two previous articles by the same authoring group, previously presented at the 16. Symposium “Design for X” [1] and the 9th International Design Conference [2]. In these papers models for various aspects of PSS development are presented. In the first contribution, a generic activity model based on the transformation model from Hubka and Eder [10] describes our fundamental understanding of a combined product and service delivery. Elaborating on this foundation, a model is developed, which describes the necessary partnering and aligning of activities of suppliers and customers in PSS settings. In the second contribution, two possible dimensions of *offer development* are investigated and illustrated. Here we utilise two further models to describe development influences from both a *product life cycle*- and a *customer relations life cycle* -perspective.

In this contribution we take the step from a fundamental understanding of the phenomenon as described in paragraphs 1 and 2 of section 2.1, to creating a normative exploitation of this understanding in the form of development tools for PSS concept development. In our normative exploitation we adopt and develop the *Customer Activity Cycle (CAC)* model, originally presented by Vandermerwe [3] into a new analysis model. Our subsequent development and tailoring of this model has been carried out by repeated application (and refining) in a number of projects conducted by *Design & Innovation* engineering students at The Technical University of Denmark (DTU). The documentation of these projects, foremost a recent project in the shipbuilding industry [4], represent the main data source for this paper.

3 The evolution from CAC to AMC

This section describes the process of developing and refining the CAC model through repeated application by D&I-students into the current *Activity Modelling Cycle* (AMC) model in

the context of study projects and the evaluation of the results by both the researchers and industry practitioners.

3.1 Origin of the activity modelling cycle

The theoretical research in PSS points towards different marketing domains, such as relational marketing and service marketing, where a similar understanding of an offers benefit is evolving [11]. Within these fields, the CAC model has been used to analyse existing and propose potentially beneficial offerings towards chosen customer segments. The original model of Vandermerwe [3] seemed well suited for an adaptation to the needs of PSS development.

3.1.1 The original CAC model

The CAC model as presented by Vandermerwe is directed towards the exploration of potential customer's activities and needs, helping to inform managers on how to shape the operational profile of their company. A central point in the argumentation is the shift from the production and distribution of industrial products to the individualised provision of support in form of services, information and supplies. Vandermerwe states that the CAC model can help to enable the company to identify the necessary offerings, and to ensure that the customer is *locked on* to the providing company by voluntarily engaging in continuous cooperation.

The model facilitates an analysis of the chosen customer group, where the activities of the potential customer initially are divided into a pre, during and post phase in relation to the utilisation of the providing company's offerings – may these initially be physical products (as e.g. animal feed in [3]) or any type of service (as e.g. air travel in [12]). The model, which is described in the following paragraphs, is illustrated in Figure 1. The model implies the notion of a repetitive cycle of activities (e.g. going on business trips by air regularly), hence the circular form and the arrows indicating the sequence of activities. After the initial setup of the model, the customers' activities are identified and arranged in sequence along the circle, in order to illustrate when and where there are opportunities of influencing the customer.

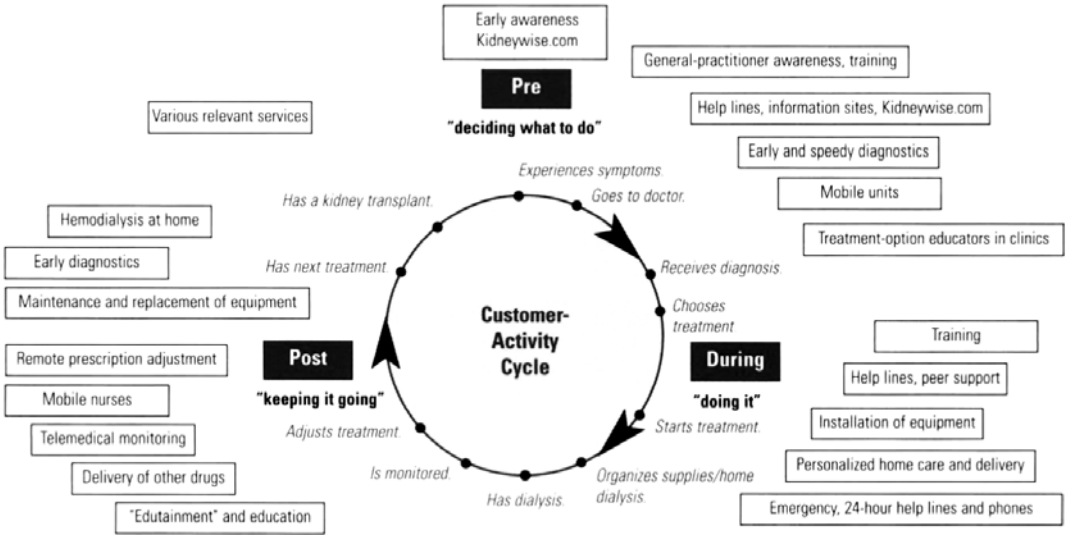

Figure 1: Potential value adding offers towards renal patients. An example of Vandermerwes use of the CAC [12].

The central point made by Vandermerwe is that the provider company should strive to be either directly or indirectly involved in all the identified activities – providing value by satisfying the customer's needs at that particular time. Based on the analysis of activities illustrated in the CAC model, the company can develop offerings that are appropriate and feasible to

support the customer in each of the modelled activities. To complete the CAC model regarding the potential and running offerings towards customers, these are arranged around the CAC and the corresponding identified activities. Figure 1 shows an example of a completed CAC model, including those proposed offerings.

Vandermerwe implies that the CAC model will help managers to create, identify and fill value gaps within their operational area, thus tying close and long lasting relationships to their customers.

3.1.2 Virtues and drawbacks of the original CAC

The original CAC model is strong in its underpinning of the importance of customer focus – which is further supported in the papers of Vandermerwe [3, 12]. The model helps articulating the meetings between a central stakeholder (customer) and the provider company represented by various offerings or mediating stakeholders. In this way, the CAC gives a good understanding of the interactions between customers and company, depending on the context of the modelling either as an analysis of the current state or as a scenario of future options. Although the customer is in the centre of both the CAC model and the concern of Vandermerwe, still it seems as if the CAC is formalising the activities and needs of a single stereotyped customer. The graphical circular setup of the model might also lead to the notion that all customers have repetitive sequential patterns of activities, which depends highly on the type of market space under analysis.

For the facilitation of the decision making process while conceptualising future offerings or strategies, the CAC has no formalised anchoring point within the providing company's core competency areas. Also concerning the customer there is no clear indication of the customer's primary need in the model. The CAC in Figure 1 for instance does not show what the central offering of Baxter should be, i.e. what is the primary carrier of value towards the customer.

On the feasibility of changing the companies operations, the CAC gives no indication of what competencies are needed and how the different offerings can support one another. The offerings are not necessarily directly connected to the identified critical activities, e.g. the *early awareness* solution in the top of Figure 1 will only be helpful for the future renal patient if he/she actually expects a renal disease and thus checks the offered information web site. Similar criticism can be applied to many of the presented examples, and it seems like the presented granularity of the CAC analysis is often to coarse (i.e. the identified activities are not specified closely enough).

Concluding on the above, the CACs main virtue is the way in which it prompts the designer into a consideration of the sequence of activities of his customer, hereby contributing to the knowledge of the designed offerings use phase. Since the CAC originally is intended for considerations in marketing offer development, it naturally disregards issues concerning the concrete delivery mechanisms necessary within the supplying company or their network partners. Also the links, dependencies and synergies between different offering elements are not made explicit.

3.2 Evolution and evaluation of the modelling tool

Despite the drawbacks described above, the CAC is found suitable to help focus the work of product development students on the changing needs of customers, thus complementing existing models dealing with the sequential progression of the product life cycle as put forward by Olesen in his thesis [13].

The adapted CAC model has been used and evolved in a study-project context over 3 years, every year applied by about 10 groups of 5 engineering students being educated under the DTU programme *Design & Innovation* (D&I). Here the model aided the student groups in the creation of PSS scenarios based on the transformation of technical appliances into combined product and service offerings, hereby focusing on the reduction of resource consumption and environmental impacts.

Throughout the projects, the model has been evolving in order to fit the demands of product development work, and elements of actor network theory [14] and the theory of dispositions [13] have been incorporated into the method and model.

Recently the model has been applied in two projects by engineering students in industry, both of roughly 4 month duration. The model has been used to explore the possibilities to expand the servicing activities of the 3 analysed companies which deliver refrigeration and flow components, integrated refrigeration and flow control systems and naval installation services respectively as sub suppliers to other companies.

All projects have been closely monitored and supervised by the researchers, thus giving insights for the evolutionary development of the model and its application method.

The results of the students' projects have been evaluated by both industry practitioners whom supplied the products and themes for the projects, and the researchers themselves.

The researchers own involvement in the application and development of the model reduces their ability to formally validate the usefulness of the models, which therefore mainly is deducted from the industrial partners' reaction to the application of the modelling technique to their specific product offers.

4 The AMC model

In this paper, the most recent student project [4] has been chosen as case. In the project, a group of students have analysed the operations of two companies in the Danish shipbuilding industry, one delivering valves and tank control systems, the other offering installation and configuration services to Danish shipyards. In the project, the students focused on processes including the projecting, building and operation of large container vessels. Throughout the project, the students gained insight in the operations of both the shipbuilding and the shipping industry, enabling them to link the competences of the two focus companies to the end customers, in this case container shipping companies operating on in the global shipping market.

4.1 Prerequisites and analyses required

The AMC is a graphical information model, which prompts the designer to consider customer's activities, involved stakeholders and the topology of the value delivery chain in an integrated fashion while working through the analyses leading to the completed AMC. Compared to the original CAC the AMC method results in a number of different graphical model views. The focus of each of these resulting models will be discussed in the following sections. During the setup of the AMC analysis, a number of prerequisite decisions must be taken, which will be discussed first.

4.1.1 The primary stakeholder

First of all, the customer or primary stakeholder has to be identified in order to have an anchor around which the analysis can revolve. As most of the work in the analysis will be di-

rected towards identifying the primary stakeholder's interests and activities, it is crucial to make a good choice.

In the case project, the ship owner (shipping company) contracting the building of the vessel was chosen as primary stakeholder, but it could have been the contracting shipyard or even shipping companies investing in 2nd-hand vessels – as these probably have more need of maintenance support. In the student project the conclusion was to acknowledge the different needs of the contracting ship owner compared to the 2nd and 3rd ship owners by proposing a change of the circular model into a modelling spiral as illustrated in Figure 2.

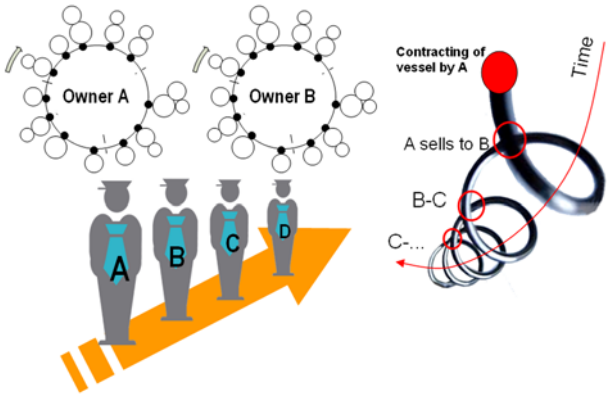

Figure 2: Necessity of developing different AMC models for different product owners in the product life cycle. Adapted from [4].

Concluding, there are two dimensions of choice when deciding on the primary stakeholder for the AMC method:

1. Deciding between the different stakeholders in the value chain: Direct customers, customers' customers or end customers. Other cases have shown that sometimes it might be interesting to focus on end customers, which are actually not stakeholders in relation to the supplier's primary products. In the actual case project, this would translate to whether the owners of the shipped goods could be considered central for the AMC analysis.
2. Following the changing ownership of the company's primary product throughout its life cycle. In the project it was decided that the interests and activities of the 1st and 2nd ship owners where so different that a separate analysis was set up for the 2nd ship owners activities.

Although the objective of engaging in a PSS oriented development project might be the re-definition of the company's operational profile, it is still necessary to be aware of what the core competencies of the organisation are, and what the primary contribution to the market space under development will be. If these fundamental concepts are not defined, it will be impossible to keep a consistent line of reasoning for the identification of the primary stakeholder's activities.

4.2 Cycles showing the current situation

As stated earlier, the AMC method results in a number of AMC model views. An example of 2 of the resulting models, one showing the activities throughout the customer's life cycle, the other showing the network of suppliers supporting this life cycle, on options of after sales services in the shipbuilding industry is shown in Figure 3.

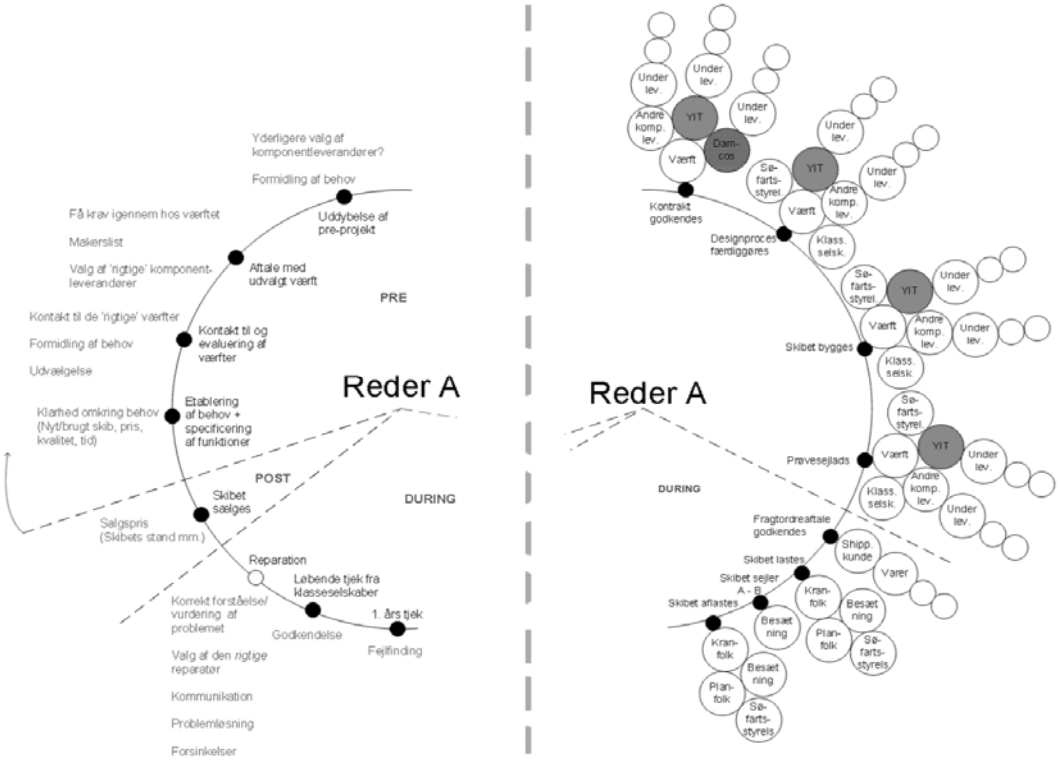

Figure 3: Two AMC models showing critical activities (left) and the delivery network (right) for service delivery in the container ship industry. Adapted from [4]

The left side of the illustration shows the *critical activity view*, where the central stakeholder's (identified in the middle of the circle) activities and the most important requirements concerning these activities are noted. The critical activity view thus connects the activities to the requirements that a proposed offering addressing that activity should fulfil. This version of the AMC model thus reduces one of the drawbacks of the original CAC in development work, as the most important performance criteria are stated explicitly.

The right side of the illustration shows the *delivery network view*, where the chain of stakeholders influencing every single activity is mapped. Usually the supplier company will be represented in some of the identified chains, which e.g. is indicated by the shading of some of the "bubbles" in Figure 3. This view enables the development team to identify what other stakeholders are involved in a certain activity pattern, and who might be approached for delivery partnerships or other cooperation.

4.3 Cycles describing future scenarios

Based on the two model views described above, future scenarios can be elaborated. The resulting general concepts can be noted as extensions of the two existing models, leading to the *activity scenario view* and the *network scenario view* represented by examples in Figure 4.

The activity scenario view corresponds to the completed CAC model of Vandermerwe (see Figure 1). It shows the scenario of activities with a description of the offer elements proposed to support the primary stakeholder. Throughout the synthesis work of the PSS concept, the sequence of activities may be changed, ensuring that the same important requirements of the primary stakeholder are met. Some of the activities previously performed by the primary stakeholder might be taken over by the supplier network and thus be replaced by other activities in the activity scenario view.

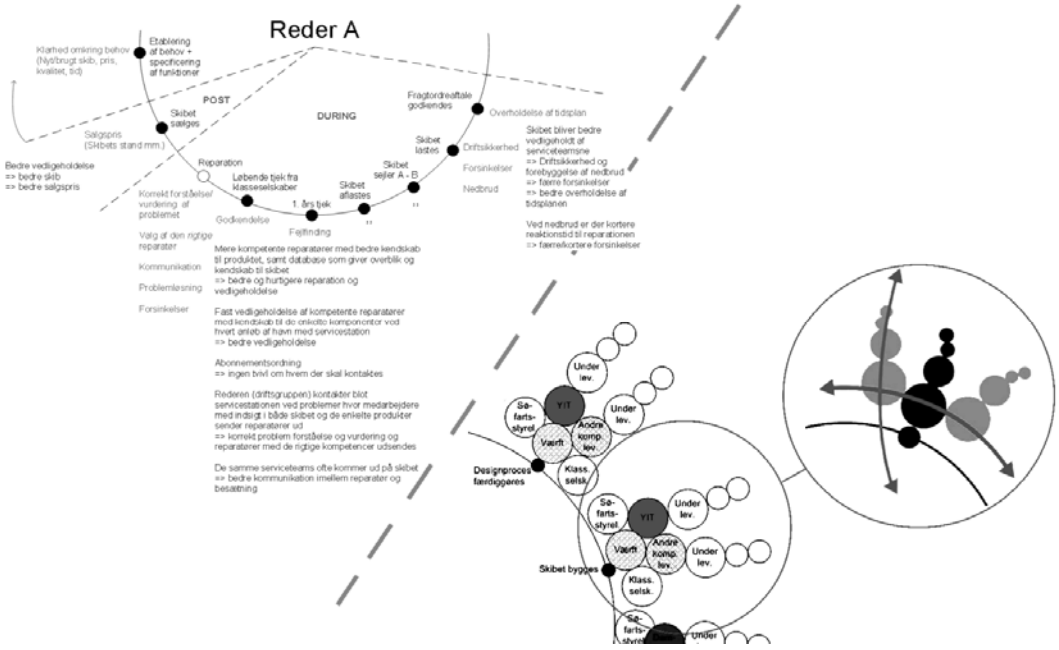

Figure 4: The AMC models describing potential future offerings (top) and possible network partnerships (bottom). Adapted from [4].

The network scenario view (in the lower right of Figure 4) shows the proposed delivery network corresponding to the activities in the scenario activity view. As indicated in the figure, network partnerships can be proposed both vertically in the delivery chain as horizontally between partners delivering to the same customer/activity. The network scenario view gives information on where the company can allocate competences necessary for the delivery of new offerings by engaging in delivery partnerships.

5 Virtues and drawbacks of the AMC

Compared to traditional schools of product development, where the life cycle of the (physical) product is considered essential, the AMC modelling process is focused on the customer or user interaction, disregarding the concrete means of value delivery. This fact makes the AMC method interesting as it opens the eyes of the designers for dimensions of development, which usually are disregarded but hold opportunities of benefit in many ways.

The analysis leading to the two first model views (critical activity view and delivery network view) inspire the designers to consider the possibilities of developing not only the product, but to actively prescribing changes in the life phase systems of the product's service life.

The activity scenario view and the network scenario view can be used to communicate parts of the synthesised concepts for the resulting changed life phase systems. Especially the network scenario view is powerful in communicating the options of partnering with other stakeholders in the value delivery chains.

Currently it seems like there is a danger of referring too closely back to the analysis views when setting up the two scenario views, especially since the results of the analysis models will tempt the designer not to change the sequence of activities. Based on this observation, the use of the AMC model to describe developed concepts is still to be further elaborated.

As stated earlier it is crucial to follow an appropriate sequence of the customer's activities, as the focus of the total offering palette is depending heavily on the choice of critical activities. As with all other methods of stakeholder analysis, the AMC model can only show the activities and requirements of a specific (stereo)type of customer, making the setup of several AMC models for different user groups necessary. In the case project this resulted in considerations whether the AMC model should be set up as a spiral, following the changing needs of consecutive ship owners as illustrated in Figure 2. A comparison with other projects where the AMC modelling technique has been applied showed that the market space in the case project is a special situation, where long living products (container vessels) go through a number of use phase loops throughout their life cycle, rendering the spiral form a special case not worth developing further.

Even in the case project, the AMC model showed shortcomings in the single stranded, sequential setup of activities, which forces the designers to reduce the complexities of the analysed use phase in order to match the simplicity of the model.

Finally, the AMC does not take the operational context of the company into account, making the proposed concepts feasibility highly dependent on the insight of the designers using the method. Also the links and possible synergies between different elements of the total offer are not expressed explicitly in the AMC model.

To summarise the result of the AMC modelling use it can be stated that the modelling technique:

- prompts designers to rethink and design the life phase systems surrounding the primary product.
- leads to concepts of wider scope compared to traditional methods focusing on the product life cycle.
- is very powerful in the communication of potential networking opportunities.
- is very powerful in the communication of potential offerings impact on the customers behaviour and activities.

What still needs to be addressed in a further development of the modelling technique is:

- the limitations in terms of complexity of the activities that can be modelled.
- the combination of the customer/user focus with the context of the delivery system.
- the visualisation of conflicts, links and synergy options between offer elements.

6 Conclusion

In the process of developing PSS, it is important to widen the scope of development – considering possibilities of e.g. cooperation with external partners, reformulation of business models or the delivery of services not closely bound to the life cycle of the primary product portfolio. The AMC modelling technique will help designers take this step, as the designer is urged to consider the appropriateness of the existing activity systems and propose optimising changes to them. To support the development of the proposed changes, knowledge of the opportunity parameters available to influence the service life phases is necessary besides the AMC models.

The AMC modelling technique still needs to be developed further to represent links, conflicts and synergies between possible offerings and operations but already works as a tool to widen the designers view on the design object including both product and activity system.

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