The Concept of Modularisation of Industrial Services

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Abstract. The paper summarises findings from an action research project on modularisation of industrial services. Based on literature about modularisation of physical goods and literature on modularisation of services, several research gaps are highlighted and appropriate approaches discussed. Module drivers addressing modularisation benefits are transferred to services. Interdependencies among service elements are presented. Research gaps on design opportunities of modular service products are addressed and possible analogies from modularisation of physical goods are introduced.

Keywords: industrial service, after-sales, service modularisation, modularity, service engineering

1 Introduction

Industrial service is an important field of business for many industrial companies, traditionally manufacturing and selling physical goods. Services benefit their customer with added value and in return increase their turnover and profitability [1].

Customers of industrial services are themselves companies often active in different businesses or on regionally different markets. Due to the variation of their business conditions their requirements regarding services (availability, intervention times, service levels) may vary.

Spath et al. [2] emphasize the need to orientate service offerings strictly towards customer requirements. In a research project with industrial partners the interest in customizing services was found. Industrial partners saw turnover potential or possible cost benefits in offering services with for instance longer or shorter lead times. A study on logistics services by Mentzer et al. [3] shows similar results. As a result of the study it is found, that different customer segments emphasise different aspects of a logistics service. Consequently, the authors suggest logistics services to be customized to cater to customer segment desires.

Contemplating the developing need to adapt service to customer specific requirements, parallels to physical goods are imposed. An widely applied and successful concept in industry is *modularisation.* It can be seen as the best way to provide variety demanded by customers [4]. Modularisation also enables standardisation and hence the realisation of economies of scale [5]. For this reason

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transferring the concept of modularisation to industrial services seems to be a promising approach to cope with the current need for efficient service customisation.

1.1 Background and objective of this paper

The transfer of the concept of modularisation raises different challenges arising from the difference between physical products and services. In literature distinct characteristics of services compared to physical products such as intangibility, inseparability and simultaneity are being discussed. The findings address challenges in transferring modularisation concepts from goods to services due to these characteristics.

While there are certain differences between goods and services, there are also many aspects they have in common [6]. Due to the parallels, the concept of modularisation may be transferrable with adaptations to industrial services. The paper will highlight aspects of modularisation that would be of benefit to transfer to services and point out promising approaches.

Literature on modularisation of services can be found already. This paper will argue that some special requirements of services remain unaddressed leaving important gaps. Hence, there is inconsistency especially when compared to concepts from physical goods industry. In order to achieve practical applicability in terms of modular services offered to customers, further research needs to be conducted.

In summary, the objective of this paper is to highlight major gaps in the concept of modularisation of services and point out promising approaches to filling these gaps.

1.2 Methodology

The paper gives insight into a research project carried out with several industrial companies active in investment goods industry. The commercial goal of the project is to allow the participating companies to establish service variants in order to enrich their service portfolio. Different workpackages address the practical needs of the companies, from the identification of useful service variants to the estimation of cost and risk for introducing a service variant.

The presented research is based on the principles of action research [11], [12]. Ideas, approaches and concepts are developed through cycling through literature and desk research, interviews with companies, company specific consultancy and joint workshops with different companies. Through presentation of preliminary findings, industrial partners are confronted with the ideas, validate the correctness and applicability and give new stimuli for refinement of the findings.

Following the collaboration with different companies the relevance beyond the special need of one industrial project partner was identified. Thus, the characteristics and requirements of action research [13], [14] were considered.

1.3 Basic definitions

Authors of literature on modularisation do not provide or use consistence terms and definitions. Especially concerning services, terminology needs clarification. For this reason, the main terms are introduced and defined briefly, forming a basis for further thoughts.

Modularisation is the action of decomposing a product into its elements, analysing interdependencies between the elements and integrating them into modules in order to reduce complexity [7]. Modularity allows changes within one module without requiring changes on other modules. A service can be decomposed into service elements on the basis of the service process.

Elements are the units of which a product is made or assembled. A service element comprises a service process element, required resources for the process and leads to a partial result of the overall service product.

There can be *interdependencies* between elements of a product, meaning that either an element influences another one or in turn it is being influenced itself [7]. Interdependencies exist, when a change on one aspect of an element requires a change on another element of the product. The interdependencies between elements can be different in strength. This definition of interdependence is applicable to services as well, but leads to the main challenges in service modularisation as highlighted in the findings.

Modules integrate elements with strong interdependencies among each other. Elements of different modules are meant to have little interdependencies, which gives modules a high degree of independence among each other facilitating exchangeability. A service module can integrate different service elements.

Interfaces between modules are needed in order to enable a coaction of different modules within the product. Often these interfaces are related to the interdependencies of the elements integrated into a module. For services, interfaces are usually related to the service process, where the output of one service process needs to be a compatible input for the succeeding service process.

The *product architecture* is the scheme by which the functions of a product are allocated to physical components, i.e. elements and modules [5]. It can be modular or integral. In practice, modularity in product architecture can be more or less extensive. Service architecture in industrial services is most likely modular to a certain degree, as processes describing a service are always a decomposition of required actions into parts.

A *service product* can be described through a three level model [8]. The top level is the *service result*, i.e. the result of a service operation visible to the customer. It can be specified through performance metrics (see table 1). The second level offers a perspective on the *processes* enabling the service result. The third level of the model addresses the required *resources* for performing the processes leading to the final result. Barney [9] identifies human resources, physical resources and information as three categories of resources.

Table 1. Attributes and possible performance indicators of service result.

Variable Attributes of a Service Result (Performance Indicators)		
Time	**Content**	**Price**
• Reaction time	• Horizontal range	• Level of price
• Service execution time	• Vertical range	• Mode of charge
• Availability time	• Quality	

A *service variant* is a service product derived from a standard service product. Both service products offer a very similar service result, but differ in a certain aspect of their performance characteristics. This difference can be specified through one or more performance metric on the service result level [10].

Through modularisation the change on only one module of the standard service product creates a service variant. Only a small part of the service would have to be redesigned allowing economies of scale for all carry-over modules. Figure 1 shows two service variants offering different service levels perceivable by the customer on the result level.

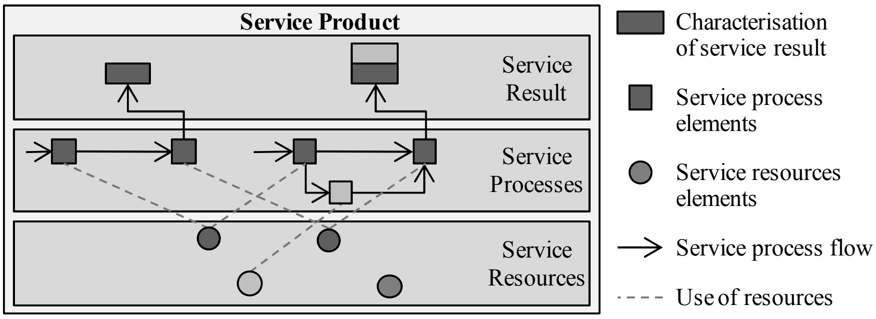

Fig. 1. Service Variants in the Service Model

2 Literature on Service Modularisation

When screening literature on service modularisation it can be found, that a few German authors have addressed the topic without tempting to offer a comprehensive transfer of the concept of modularity to industrial services.

Burr [15] discusses the opportunities and threats of modularisation of industrial services. The evaluation is founded on the resource-based view of the firm. After a short overview on the concept of modular service architecture, the effect of exploitation and exploration of resources through modularisation of services is analysed.

Hermsen [16] develops a construction kit for customized configurations of product related services based on existing service products with a high variety of service processes. His approach bases on modular service objects, i.e. service processes, which are modelled in a UML (unified modelling language) related form (meta-model). A predefined construction kit, containing all service processes currently being carried out in the company is compiled to a digital landscape of all service processes.

Corsten [17] points out that from a coordination point of view there are other interdependencies apart from the process output-input interdependence. These are evaluated qualitatively in a design structure matrix (DSM). Mathematical algorithms are used to reorder the process elements aiming at modules to be performed by one organisational unit.

Bohmann et al. [18] discuss modular service architectures on a theoretical basis and give a practical example from IT industry. After highlighting the relevance of modularisation for services the principles of modularisations are presented generically with illustrating examples. Additionally modularisation is put in relation to service engineering, supporting the development of innovative service products.

All authors contribute valuable aspects to transferring modularity to services. Nevertheless, important aspects related to the key characteristics of services remain unaddressed, leaving gaps for further research as the findings show.

3 Findings

In the findings, insights and thoughts from the research project not covered by existing literature are summarized. The findings are structured into three categories, raising challenging questions each and relating to concepts from physical goods industry that may be transferred and used to approach the questions.

3.1 Reasons for Modularisation

Ulrich [5] states that modularisation of products is not free of cost and will not necessarily result in economical benefits for a company. Therefore a clear objective related to economical benefits needs to be defined. Although Burr [15] discusses the benefits of service modularisation from a resource point of view, possible objectives or benefits remain unnamed.

This paper emphasizes the benefit of offering service variants based on a modular service architecture due to the character of the research project with industrial partners. However, other objectives may exist. In modularisation of physical goods various *module drivers* (module indicators) are named each emphasising a different reason why an element of a product should be integrated into a module [19] [20] [21] [22] [23]. Table 2 shows an overview of the module drivers in physical goods industry and possible analogue reasons for modularising industrial services.

Table 2. Module drivers for physical goods and according analogies for industrial services

Module driver for physical goods	Analogy for industrial services
• Functional interdependence	• Are functional interdependencies facilitated?
• Isolation of risk	• Can service elements with high risk of failure be isolated?
• Assembly requirements	• Are similar resources required in order to perform service?
• Sourcing capabilities	• Are capabilities of different organisational units considered?
• Standardisation potential	• Are service elements carried out often in a standardized way?
• Concentration of change	• Will service elements be replaced in the future?
• Concentration of variability	• Can the exchange of service elements create a variant?
• Geometrical independence	• --
• Facilitate maintenance	• Are service elements likely to fail concentrated for easy recovery?
• Input-Output relations	• Do service elements input-output interdependencies exist?
• Testing	• --
• Recycling	• --

3.2 Analysis of interdependencies

Interdependencies are usually assessed through the different module drivers. Thinking of industrial services from the model perspective of Meffert & Bruhn [8], the interdependencies between service elements show a different complexity compared to physical goods. Figure 3 shows the interdependencies one service element can have to another one, affecting the way elements are bundled into modules and the way a change on one service element or module may affect the rest of the service product.

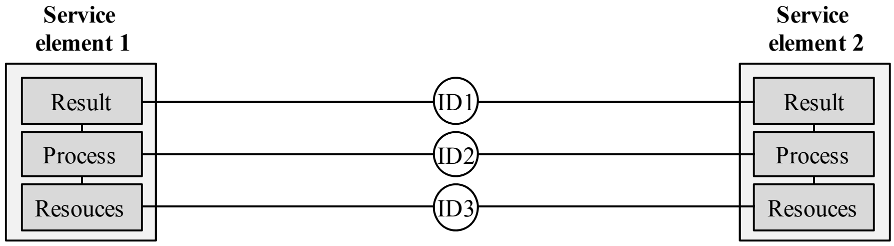

Fig. 2 Interdependencies between service elements

ID1 addresses the interdependence between the results of two service elements. Changing the lead time of element one may for instance require changes on other service elements in order to have an impact on the overall product result. The content of service element one in contrast may be effective without changing any of the other service elements in the service product. For example, reducing delivery times for a spare part would be of no use, if the technician fitting the part into the machine is not be available in a similar range of time. Still this important aspect has not been addressed. Applying quality function deployment (QFD) for unveiling these interdependencies is useful especially when the designing of service variants is relevant.

ID2 addresses the interdependencies of the processes in terms of their output-input relationship. This interdependence affects the timely order in which the processes have to be performed. These interdependencies can be clarified in a service blueprint [24] or in a time-based design structure matrix (DSM) [25]. The DSM then allows a reordering of the process elements in order to avoid interdependencies between the service elements. For example can loops in different processes be identified, rated and possibly reduced.

ID 3 addresses the interdependencies there are between resources of different service elements. There are two possible interdependencies: First, the compatibility of resources and second the capacity interdependence. The compatibility interdependence addresses for instance language skills of workers or technical restrictions of used equipment that need to match resources applied in another service element. The capacity interdependence is of relevance when different service elements require identical resources. This interdependence may affect attributes on the service result level and hence is very important for the creation of service variants.

3.3 Design Opportunities

A service variant is created through exchanging one service module through another. These changes can be achieved through changes within a module or element on the process level or on the resource level [10]. But through change of the process or resources, the interdependence to other modules of the service product may be affected, as discussed above. Identifying possible generic changes on a service module for different attributes on the service result level can be elaborated and rated by their impact on other modules through the given types of interrelations.

In modularisation of physical products Baldwin & Clark [7] argue, that all possible design changes are realised basically by six simple modular design operators. An analogy for industrial services highlighting design opportunities and giving insight into their impact on interdependencies would be of help for practical application of the concept.

Ulrich [5] as well as Ulrich & Tung [26] characterise different types of modularity in respect to the criterion of how the final product is built and about the nature of the interface. The different types of modularity like component swapping, combinatorial [27], fabricate-to-fit, bus, sectional or slot modularity all offer different potential in respect to the different module drivers. An analogy for industrial service would clarify design opportunities in terms of guidelines on how to achieve a specific goal through modularisation of services.

4 Conclusion and Outlook

In the present paper an overview on the topic of service modularisation was given from a perspective of enabling the efficient creation of service variants. A comparison between literature on modularisation of physical products and literature on service modularisation highlighted aspects relevant to practical application and not covered by research to date. Literature on modularisation of physical goods does not address specific requirements of industrial service in terms of their process and resource related character. An adaptation of existing concepts on modularisation of physical products would be required.

Literature on modularisation of industrial services already addresses different aspects of the topic. But still there are interesting and challenging questions remaining as the findings summarise.

Finally, the future theoretical findings are to be brought to practical application. Procedure models as developed in the community of service engineering are an appropriate mean to achieve practical acceptance and use.

References

1. Koudal, P.: The Service Revolution in Global manufacturing Industries. Deloitte Research. 2 (2006)
2. Spath, D., Zahn, E.: Kundenorientierte Dienstleistungsentwicklung in deutschen Unternehmen. Springer. Stuttgart (2003)
3. Mentzer, J., Flint, D., Hult, T.: Logistics Service Quality as a Segment-Customized Process. J. of Marketing. 65, 82--104 (2001)
4. McCutcheon, D.M., Raturi, A.S., Meredith, J.R.: The customization responsiveness squeeze. Sloan Management Review. Vol. 35. Iss. 2. 89--99 (1994)
5. Ulrich, K.T.: The Role of Product Architecture in the Manufacturing Firm. Research Policy, Vol. 24. 419--440 (1995)

6. Morris, B., Robert J.: Dealing with Inherent Variability: The Difference between Manufacturing and Service? IJ of Production Management, Vol. 7, Iss. 4. 13--22 (1987)
7. Baldwin, C.Y., Clark, K.B.: Design Rules: The Power of Modularity, Volume 1. Cambridge, MA: MIT Press (2000)
8. Meffert H., Bruhn, M.: Dienstleistungsmarketing: Grundlagen, Konzepte, Methoden. Gabler, Wiesbaden (1995)
9. Barney, J. 1991. Firm Resources and Sustained Competitive Advantage. In: J of Management; Vol. 17. Iss. 1. 99--121 (1991)
10. Seite, F., Nobs, A., Minkus, A.: Flexibility of Resources in Global After-Sales Service Networks. Proceedings of the 5th International Symposium on Management, Engineering and Informatics (MEI 2009), Orlando, 132--137 (2009)
11. Eden, C., Huxham, C.. Action Research for Management Research. British J of Management, Vol. 7, Iss. 1, 75--86 (1996)
12. McKay J., Marshall, P.:The dual imperatives of action research. Information Technology & People, Vol. 14, Iss.1. 46--59 (2001)
13. Susman, G.I., Evered, R.D.. An Assessment of the Scientific Merits of Action Research. Administrative Science Quarterly, Vol. 23, 582--603 (1978)
14. Baskerville, R.: Distinguishing Action Research From Participative Case Studies. Journal of Systems and Information Technology. Vol. 1. Iss. 1. 25--45 (1997)
15. Burr, W.: Chancen und Risiken der Modularisierung von Dienstleistungen aus betriebswirtschaftlicher Sicht. In: Herrmann, T., Kleinbeck, U., Krcmar, H.: Konzepte fur das Service Engineering. 17--44. Physica, Heidelberg (2005)
16. Hermsen, Martin: Ein Modell zur kundenindividuellen Konfiguration produktnaher Dienstleistungen : Ein Ansatz auf Basis modularer Dienstleistungsobjekte. Aachen : Shaker, 2000. Bochum, Univ., Diss., (2000)
17. Corsten, H., Dresch, K., Gossinger, R.: Gestaltung modularer Dienstleistungsproduktion. In: Bruhn, M., Strauss, B.: Wertschopfungsprozesse bei Dienstleistungen. 96--117. Gabler, Wiesbaden (2007)
18. Bohmann, T., Krcmar, H.: Modular Servicearchitekturen, In: Bullinger, H.J., Scheer, A.-W (eds.): Service Engineering. Entwicklung und Gestaltung innovativer Dienstleistungen, 2. Aufl., Berlin, pp377-401, (2006)
19. Blackenfelt, M.: Managing Complexity by Product Modularisation: Balancing the Aspects of Technology and Business during the Design Process. Stockholm, Royal Institute of Technology, Dept. of Machine Design, Diss (2001)
20. Ericsson, A., Erixon, G.: Controlling Design Variants: Modular Product Plattforms. Dearborn, MI: Society of Manufacturing Engineers (1999)
21. Goepfert, J.: Modulare Produktentwicklung: Zur gemeinsamen Gestaltung von Technik und Organisation, Dissertation, Dt. Univ.-Verlag; Wiesbaden (1998)
22. Koeppen, B.: Modularisierung komplexer Produkte anhand technischer und betriebswirtschaftlicher Komponentenkopplungen, Shaker, Aachen, Diss (2008)
23. Wildemann, H.: Produkte & Services entwickeln und managen, Strategien, Konzepte, Methoden; 1.Auflage, TCW Transfer-Centrum GmbH & Co. KG, München. (2008)
24. Shostack, L.: How to design a service. In: European J of Marketing. Vol.16. Iss.1. p.49 (1982)
25. Browning T.: Applying the design structure matrix to system decomposition and integration problems: a review and new directions. IEEE Trans Eng Management. Vol. 48. Iss. 3. 292—306 (2001)
26. Ulrich, K.T., Tung, K.,. Fundamentals of Product Modularity. Working Paper WP3335-91-MSA. MIT Sloan School of Management. Cambridge, MA (1991)
27. Salvador, F., Forza C., Rungtusanatham, M.: Modularity, product variety, production volume, and component sourcing: Theorizing beyond generic prescriptions," J. of Operations Management.,Vol. 20. 549--575 (2002)