**International Journal of Operations & Production Management**

# Service decomposition: a conceptual analysis of modularizing services

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Received 24 June 2015
Revised 24 June 2015
Accepted 21 July 2015



# Service decomposition: a conceptual analysis of modularizing services

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## Abstract

**Purpose** – Applying "modularity" principles in services is gaining in popularity. The purpose of this paper is to enrich existing service modularity theory and practice by exploring how services are being decomposed and how the modularization aim and the routineness of the service(s) involved may link to different decomposition logics. The authors argue that these are fundamental questions that have barely been addressed.

**Design/methodology/approach** – The authors first built a theoretical framework of decomposition steps and the design choices involved that distinguished six decomposition logics. The authors conducted a systematic literature search that generated 18 empirical articles describing 16 service modularity cases. The authors analysed these cases in terms of decomposition logic and two main contingencies: modularization aim and service routineness.

**Findings** – Only three of the 18 articles explicitly addressed the service decomposition by reflecting on the underlying design choices. By unravelling the decomposition in each case, the authors were able to identify the decomposition logic and found four of the six theoretically derived logics: single-level process oriented; single-level outcome oriented; multilevel outcome oriented; and multilevel combined orientation. Although the authors did not find a direct relationship between the modularization aim and the decomposition logic, the authors did find that single-level decomposition logics seem to be mainly applied in non-routine service offerings whereas the multilevel ones are mainly applied in routine service offerings.

**Originality/value** – By contributing to a common understanding of modular service decomposition and proposing a framework that explicates the design choices involved, the authors enable an enhanced application of the modularity concept in services.

**Keywords** Modularity, Decomposition logic, Service offering

**Paper type** Literature review

## 1. Introduction

In the past decade, increasing attention has been given to the application of modularity principles in the design of service offerings as modular design principles have been suggested as a way to provide variety at relatively low costs (De Blok *et al.*, 2010a, b; Voss and Hsuan, 2009). Modularization enables an increase in standardization whilst safeguarding the required level of customization. Modularity in its most abstract sense refers to the degree to which it is possible to separate and recombine a system's

International Journal of Operations & Production Management
Vol. 36 No. 3, 2016
pp. 308-331

0144-3577
DOI 10.1108/IJOPM-06-2015-0370

parts (Schilling, 2000). Modularity is widely applied and researched in product design. In product modularity, a module refers to a unit whose structural elements are strongly connected among themselves but weakly connected to other units (Baldwin and Clark, 2000). For example, in computer design, the monitor, the mouse, the keyboard and the processor can all be considered as modules. The study of modularity has since been extended to service systems. Rajahonka (2013) defines a service module as a relatively independent part of a service offering with a specific function and standardized interface.

A crucial question in service modularization is how to identify the individual parts of a service offering and how to determine which of these parts – alone or together – can be designed as modules (Salvador *et al.*, 2002). This question relates to the decomposition logic: the explication of the design choices involved in decomposing a service offering into modules. One issue in this debate involves how services' multidimensional nature influences their decomposition into modules. That is, unlike with product offerings, service offerings not only have an outcome but also a process dimension (Goldstein *et al.*, 2002; Grönroos, 2000). On this basis, Pekkarinen and Ulkuniemi (2008) distinguish between service product modules and service process modules. In contrast, Chorpita *et al.* (2005) decompose the service offering into modules that combine both outcome and process dimensions. Another decomposition design choice concerns the level of decomposition, and this also varies between studies. For example, Voss and Hsuan (2009) chose four decomposition levels: industry, service company, service bundle and service component; whereas Moon *et al.* (2009, 2011) took a different angle by decomposing into service families, services, modules, components and attributes. As a consequence of the different decomposition logics in the literature, the label "module" is applied to a wide variety of service parts.

Given the presented conceptual definition of a module, decomposition logic matters. Decomposition results in: first, the encapsulating of interdependencies within self-contained functional parts that can be conceptualized as modules; and second, the minimizing of reciprocal dependencies between these modules (Ethiraj and Levinthal, 2004; Simon, 1962). These two main features give a modular design the following advantages. First, modularly decomposed services afford incremental and localized innovation and optimization within modules without affecting the overall design and thus help reduce design complexity (Ethiraj and Levinthal, 2004). Further, minimized reciprocal dependencies allow for standardized interfaces, i.e., "the set of rules and guidelines governing the flexible arrangement, interconnection, and interdependence of service components and service providers" (De Blok *et al.*, 2014, p. 30), and this reduces coordination costs. Finally, as each module represents a distinct service function, the separate modules can be flexibly and efficiently recombined to meet specific customer demands.

Whilst the service modularity literature offers diverse examples of decompositions leading to a wide variety of modularity types, a conceptualization of the underlying service decomposition logics is lacking. This paper, therefore, seeks to identify and compare different decomposition logics for modularizing service offerings. Our contribution to the service modularization literature is twofold. First, we provide a typology of service decomposition logics and an overview of decompositions and the resulting modularity types found in the literature. Second, by comparing the different decomposition logics found, we explore how these differences are related to two main contingencies, i.e. the modularization aim (Campagnolo and Camuffo, 2010) and service characteristics. Whilst the service modularity literature recognizes the relevance of the modularization aim (Bask *et al.*, 2010; Geum *et al.*, 2012) and of service characteristics (Bohmer, 2005), the possible relationships of these contingencies to the decomposition logic have not been analysed. To these ends, we conducted a systematic review of empirical research papers on service modularity. From this, we identify the design choices underlying service decomposition and develop contingency-based arguments for these choices.

In Section 2, we develop a theoretical framework that conceptualizes service offering decomposition as consisting of three, partly iterative, steps. We discuss the design choices involved in each step. Together, these design choices constitute the decomposition logic. Guided by this framework, we then develop three research questions to analyse the decomposition logics found in empirical research papers and to explore whether the contingencies selected affect the design choices made. In Section 3, we explain how the papers were selected and how we analysed the embedded cases contained therein. Section 4 provides the findings from this analysis, on which we then elaborate in the discussion. In the conclusions, we consider the implications of our findings.



## 2. Service decomposition logic and contingencies involved

### *2.1 Decomposition logic: the constituting design choices*

A modular decomposition logic aims to divide the service system into subsystems that each fulfil a specific function whereby the dependencies within these resulting subsystems are maximized and those between subsystems minimized (Baldwin and Clark, 2000; Salvador *et al.*, 2002; Ulrich, 1995). Below we explain how decomposing a service offering, therefore, involves three consecutive, though partly iterative, design steps: first, defining the boundaries of the service offering that will be decomposed; second, determining the decomposition level(s) on which functional parts will be identified; and third, identifying the relevant interdependencies and isolating them (Brusoni, 2005; Simon, 1962; Ulrich, 1995). Our theoretical framework is structured around the design choices involved in the three steps. Together, these design choices constitute the decomposition logic.

The first step in modular service decomposition involves defining the boundaries of the system to be decomposed (Simon, 1962). The boundaries of a service offering can refer to both the outcome ("what" is delivered) and the process dimension ("how" that service is delivered, Grönroos, 2000). The outcome dimension describes the bundle of services, both tangible and intangible, offered and includes the reasons for the service provider existing and for customers going to the service company (Grönroos, 2000). The process dimension refers to the interactions between the service provider and the customers and to the activities that need to be carried out to transform customer inputs into service outputs, i.e., service specification, production and delivery. Thus, this first decomposition step involves making a design choice over the "decomposition orientation", which may be outcome oriented, process oriented, or a combination of outcome and process orientations.

The second step in the decomposition involves identifying subsystems within the defined service offering; that is, service parts with a specific function. Functions are commonly expressed in linguistic terms such as "providing", "helping" and "facilitating" (Ulrich, 1995). Here, a design choice also has to be made because functional parts can be defined on various decomposition levels (Ulrich, 1995). Functional parts can be formulated on the level of an overall service offering (e.g. helping people to overcome depression) or on a detailed level of activities (e.g. teaching a relaxation exercise). This is in line with Simon's (1962) idea of hierarchical systems. In decomposing a service offering, a design choice is on which decomposition level(s) "candidate" functional parts, that may become modules, will be identified.

The third step in modular service decomposition involves analysing interdependencies to ensure that the parts that make up a module are mutually interdependent and that the interdependencies between modules are minimized (Baldwin and Clark, 2000; Campagnolo and Camuffo, 2010). This decomposition step draws on the idea of "nearly decomposable", as discussed by Simon (1962), who theorized that, in the short run, the behaviour of the decomposed parts should be relatively independent. In analysing the dependency patterns, we draw on Thompson's (1967) hierarchical typology of three distinct dependency types: pooled, sequential and reciprocal. Pooled dependence is the loosest form of dependence where each part or module fulfils fully independent functions whilst drawing on common resources (Thompson, 1967). Sequential dependence occurs when one module's output is another's input. Reciprocal dependence is the most complex form, and is similar to sequential dependence but with a cyclical effect. The design choice made in this step revolves around the types of interdependencies between subsystems accepted and designated as module candidates in step 2. As such, it may be necessary to iterate between steps 2 and 3.

Together, the decomposition steps (boundary setting, decomposing on one or more levels, minimizing interdependencies) constitute the service decomposition. The logic underlying this decomposition is represented in the design choices that are made: i.e., the "decomposition orientation", the "decomposition level" and the "dependencies allowed". Given the theoretical possibilities in the first two choices, there are six distinct decomposition logics. For each of these logics, a subset of dependency types can be present as indicated in Figure 1.

*2.2 The decomposition logic as reflected in the modularity types*

The design choices made during the decomposition steps are reflected in the resulting modularity types. That is, the choices made during decomposition determine what

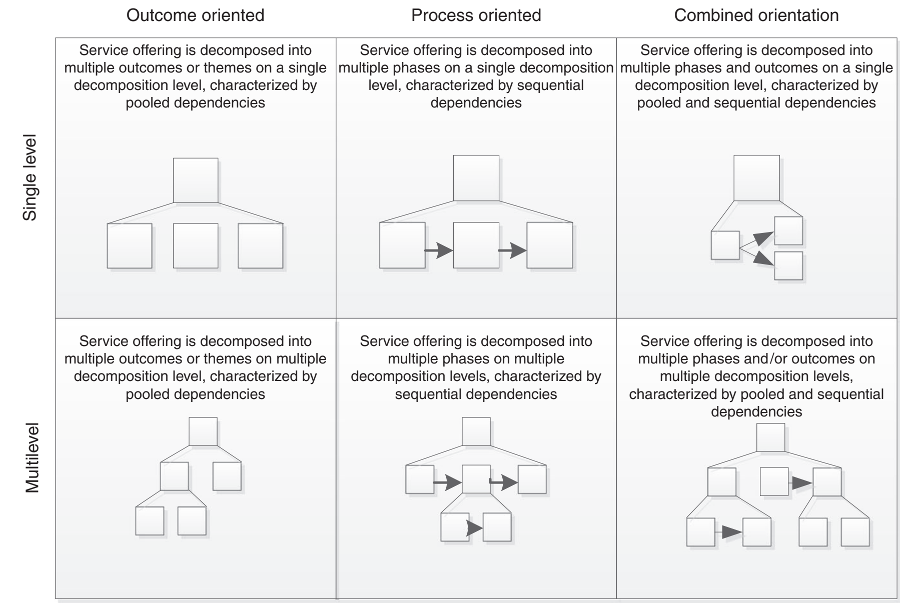


**Figure 1.** Overview of decomposition logics

kinds of subsystems become modules and in which ways the modules within a service offering can be related. Ulrich and Tung (1991) developed a modularity typology for products that distinguishes the following types: component sharing, component swapping, cut-to-fit, mix, bus and sectional modularity. With appropriate modification, these six types can be applied to service offerings. The most important modification entails the inclusion of both outcome and process dimensions of service offerings (Grönroos, 2000). The adapted modularity types and their characteristics are depicted in Figure 2.

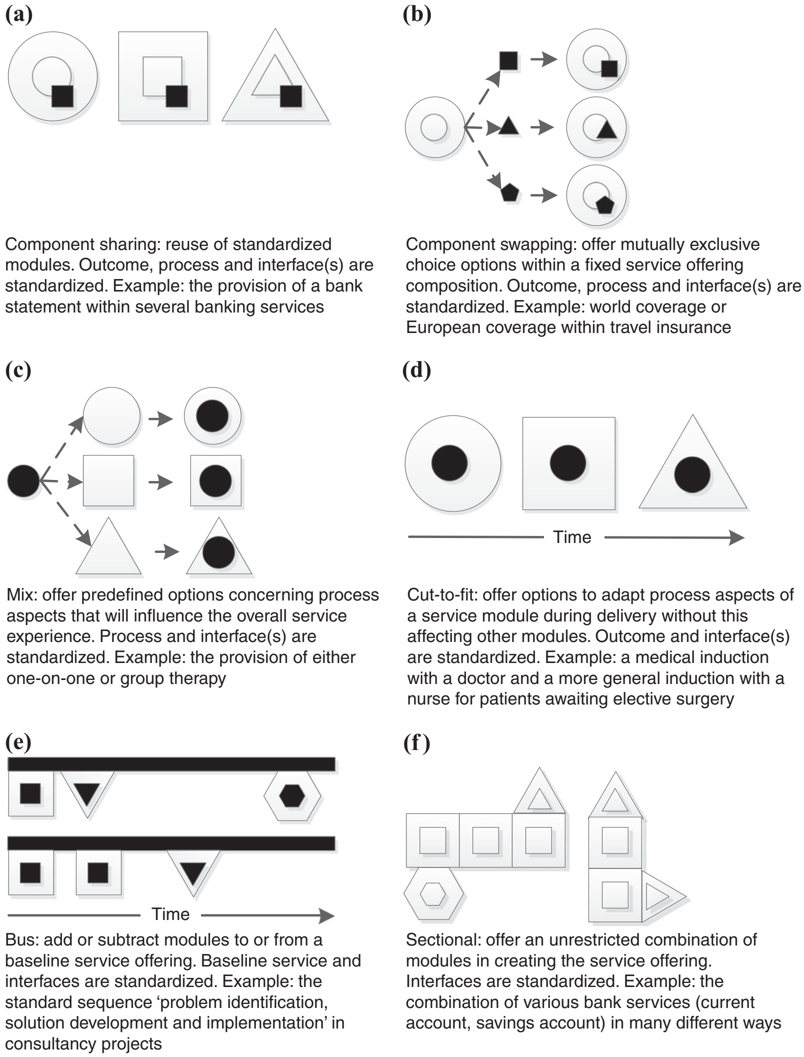


**Figure 2.** Different types of service modularity

**Notes:** Inner circle, box, triangle: service outcome dimension; Outer circle, box, triangle: service process dimension; Black: standardized

**Source:** Adapted from Ulrich and Tung (1991)

Thus, as with product offerings (Salvador *et al.*, 2002), decomposing a service offering may lead to different modularity types. Currently, what constitutes a module in a service offering, and how service offerings can be decomposed into modules, is vague (Voss and Hsuan, 2009). This lack of clarity and certainty hampers the development of scientific knowledge, as well as the effective application of a modular approach in practice. As such, there is a need to systematically analyse and critically reflect upon the different service decompositions. This leads to the first research question:

*RQ1.* What decomposition logics, in terms of design choices, are used in decomposing service offerings into modules, and what modularity type(s) result?

In the next two subsections, we elaborate on the contingencies that might affect the design choices.

### *2.3 Modularization aim and decomposition logic*

The modularization aim is the first contingency that we expect to be related to the design choices concerning a decomposition logic. As in production environments (Campagnolo and Camuffo, 2010), the modularization aim might emphasize increasing variety or gaining efficiency through lowering costs. When the aim stresses variety, the decomposition logic is expected to be outcome oriented and may restrict the dependencies between the decomposed parts to pooled ones. In this way, the variety becomes transparent for customers, who can then mix and match service parts in a wide variety of ways.

In contrast, when the modularization aim stresses enhancing efficiency through lowering costs, the decomposition logic may be process oriented and allow the dependencies between parts to be both pooled and sequential. Here, the potentially limitless "ad hoc" range of combinations is limited to pre-specified sequences of service modules. This will reduce the coordination costs of combining these modules. Moreover, decomposing a service offering into modules on a detailed level leaves fewer opportunities for personalization, putting more emphasis on standardization, which reduces costs.

The above arguments suggest that the modularization aim, provided it is explicated in advance, directs the design choices. Geum *et al.* (2012) argue that the modularization aim should "drive" the modular service design (and not vice versa). This leads to our second research question:

*RQ2.* How is the modularization aim related to the service decomposition logic and modularity type(s)?

### *2.4 Service characteristics and the decomposition logic*

The service characteristics that we specifically expect to be related to the decomposition logic concern the "input and throughput uncertainties" that make up the service routineness. Services differ in the extent to which customers' inputs and customer interactions may affect the service (Larsson and Bowen, 1989). Customers may provide information, assets or themselves as inputs to the service production process. The extent to which these inputs are known to the service organization prior to the actual service encounter varies, creating input uncertainty. Throughput uncertainty refers to the lack of predictability and structure in the service delivery process and to the interdependencies among the required activities (Mills and Posner, 1982). Service offerings with high levels of throughput uncertainty are often targeted at solving complex and ill-structured problems that are characterized by multiple perspectives (Broekhuis and van Donk, 2011) and that may be hard to decompose on a detailed level. This leads to our third research question:

*RQ3*. How is service routineness, in terms of input and throughput uncertainties, related to the decomposition logic and modularity type(s)?

## 3. Method

### *3.1 Literature search and paper selection*

We carried out a systematic literature review (Tranfield *et al.*, 2003) to identify empirical research on service decompositions. We searched the ISI "Web of Science" database and included all the likely subject areas in order to include a wide range of journals as modularity is a concept used in various fields (production and operations management, healthcare, IT, general management and engineering). We searched for the following keywords in the article titles: module, modular*, platform* or architecture* in combination with the keyword: service*. We searched for English-language articles published between January 2000 and August 2013 in peer-reviewed journals, as the concept of modularity had not been previously proposed in service contexts. This initial search resulted in 1,133 articles.

The following inclusion and exclusion criteria were used to further identify appropriate articles:

- Only articles that specifically focused on modularizing service offerings were retained. We searched the titles and abstracts for phrases such as service offering, service family and service design, and for specific service types such as banking, healthcare, psychology and logistics. We excluded articles that used services as a context rather than as the main object to be decomposed or modularized.
- We included articles that provided case descriptions based on empirical data of how service offerings were decomposed or descriptions of what could be considered as modules. Here, we searched titles and abstracts for terms such as example, module description, case, empirical and experiment. We excluded articles that only discussed service modularity on a conceptual level or that used case descriptions of products, robotics, ICT, mobile platforms or software rather than service offerings.

After an initial screening based on these criteria, 204 articles remained and these were examined in detail. We found that the majority of these articles discussed modularity in the design of websites or software, and only used services as a context (e.g. the technical modules in a website for tourist services). These technology-oriented papers did not discuss a service offering decomposition. Eventually, 11 articles remained that met our criteria. We then went through the reference lists of these 11 articles and searched for citations in the ISI "Web of Science" database. This search resulted in seven additional articles that were appropriate for inclusion. As such, our final selection amounted to 18 articles.

### *3.2 Data coding and analysis*

A preparatory step in the data analysis was to read the 18 selected papers and extract the available data on the cases described. Based on these secondary data, we conducted within-case analyses to determine the decomposition logic in terms of the design choices made and the resulting modularity type(s). For each case, we first reviewed the case information to determine where the boundaries of the service offering had been set, i.e., "what" was the service system being decomposed. Where the service system was regarded as a service offering that was being split up into smaller deliverables to the client, we categorized the decomposition as "outcome oriented". When the case described a service delivery process that was being divided into its constituting activities, we categorized the decomposition as "process oriented". We carefully checked in every case whether both outcome and process dimensions had guided the decomposition into service parts, and in such instances, we classified the case as having a "combined orientation". Next, we determined on how many decomposition levels the modules' functions had been specified and, on this basis, further categorized the cases as either "single-level" or "multiple-level" (i.e. hierarchical) decompositions. Third, we analysed the interdependencies between the decomposed service parts (whether they were only pooled, also sequential or even reciprocal) (Thompson, 1967). Excerpts from these within-case analyses of service decomposition can be found in Table I.

Given that theoretical refinement is recommended during the data analysis when undertaking exploratory case study research (Eisenhardt and Graebner, 2007), we iterated between theory and data. Here, one researcher analysed all the cases whilst three other researchers independently analysed subsets of the identified cases. In this phase, the four researchers met several times and also commented between meetings on one another's proposed categorizations. In this research phase, a number of iterations between the conceptual framework and the data were made to arrive at clear and robust categories, with unequivocal labels, enabling consensus on assigning the cases to specific categories.

The next step in these within-case analyses was to determine the modularity types applied in each decomposition. We recognized that decomposing a service system might involve a combination of modularity types.

Our approach for analysing the contingencies was as follows. First, we determined the modularization aim. All statements referring to the reasons for modularization were collected together using the original wording contained in each paper and then categorized as emphasis on efficiency through lowering costs; emphasis on variety; or emphasis on balancing variety and efficiency through lowering costs. The categorizations were reviewed by all four researchers.

To determine the routineness of a service, we studied the information on each case and classified the input and throughput uncertainties as either high, medium or low, based on to the following operational criteria. The classification of input uncertainty addressed both variety in demands and customers' disposition to participate in the service process (Larsson and Bowen, 1989). The input uncertainty is considered high (vs low) when demands for the service offering are highly heterogeneous (vs homogeneous) and involve customers who tend to participate actively (vs passively) in configuring their service offering. Input uncertainty was classified as medium if scores were in between. Throughput uncertainty was considered high (vs low) when it was impossible (vs possible) to predict the entire process in terms of the nature, number and sequence of activities involved. A medium score was attached when the sequence of activities in the delivery process was pre-specified to some extent. The interpretations and categorizations were discussed among the researchers until all four agreed upon the ratings of the two concepts. Based on this review of the input and throughput

**Table I.**
Overview of service decompositions identified in the cases

| Case | General description of the decomposition, including its boundaries | Decomposition orientation | Decomposition levels | Remaining dependencies between decomposed parts |
|---|---|---|---|---|
| 1. Post and package services (Bask *et al.*, 2010) | (a) Decomposed into: letter, e-post, package, warehousing<br>(b) In turn these were decomposed into: activities (printing, pick up, sorting, terminal-to-terminal transport) and choice options concerning delivery mode (electronic delivery, home delivery, pick up, direct distribution) | Service outcome and process | 2 | (a) Pooled<br>(b) Sequential |
| 2. Outpatient care for chronic hypertension (Bohmer, 2005) | Decomposed into different treatment types for hypertension: weight control, diet modification, drug therapy, stress control, ongoing surveillance | Service outcome | 1 | Pooled when offered separately, reciprocal when modules are combined |
| 3. Lifestyle management programme (Bushe *et al.*, 2008) | Weight management programme decomposed into sessions on: healthy living, physical activity, the food pyramid, recommended food servings, fat and salt in your diet, healthy and unhealthy eating habits, high fibre diets, controlling your hunger | Service outcome | 1 | Pooled or sequential |
| 4. Psychiatric care (Chorpita *et al.*, 2005) | (a) Treatments for three types of psychological problems are distinguished: disruptive behaviour, anxiety, depression<br>(b) Subsequently, 55 "practice elements" are identified (i.e. a clinical technique or strategy that can be used as part of a larger intervention plan)<br>(c) Practice elements were redesigned as modules with specific functions (e.g. "getting acquainted" was constructed to reflect the relationship and rapport building practice elements)<br>(d) Coordination modules provided for each problem type (i.e. sequences of modules) | Service outcome and process, as well as, coordination processes | 3 | (a) Pooled<br>(b) Some combinations are reciprocal<br>(c) Pooled and sequential<br>(d) Pooled |

(*continued*)

| Case | General description of the decomposition, including its boundaries | Decomposition orientation | Decomposition levels | Remaining dependencies between decomposed parts |
|---|---|---|---|---|
| 5. Homecare for elderly (De Blok *et al.*, 2010a, b, 2012) | Homecare for the elderly was decomposed into different service types: assistance with heavy household tasks, assistance with showering and getting dressed, meals on wheels, financial advice, housing modifications | Service outcome | 1 | Pooled |
| 6. Restaurant service (Geum *et al.*, 2012) | (a) The service process is decomposed into activities and, simultaneously, facilities, supporting processes and management processes are also part of this decomposition<br>(b) The wide range of parts are recombined into modules based on interdependency patterns (i.e. general management, inventory management, reception, payment, customer guiding, customer management, order management, actual service) and module drivers (facility, waiting management, welcome process, branch management, inventory management, education, general management, and serving) | Service outcome and service process; as well as facilities, supporting processes and management processes | 2 | (a) Could not be determined<br>(b) Sequential |
| 7. Logistic service (Lin and Pekkarinen, 2011) | (a) Five service modules identified based upon customer needs. The service modules are not described<br>(b) Each service module can be further decomposed into processes and activities. The "information management" service module is decomposed into inventory record management, order processing and order tracking. Order processing is decomposed into order receiving, order scheduling, order picking | Service outcome and process | 2 | (a) Could not be determined<br>(b) Sequential |

(*continued*)

**Table I.**

Table I.

| Case | General description of the decomposition, including its boundaries | Decomposition orientation | Decomposition levels | Remaining dependencies between decomposed parts |
|---|---|---|---|---|
| 8. Case management services (Meyer *et al.*, 2007) | The "activities" performed by case managers across multiple care sites are decomposed into different sets of tasks. Each set of tasks ends with a plan, or decision, which serves as input for the next set of activities: care planning, care facilities, discharge planning, discharge, utilization review, quality assurance | Service process | 1 | Sequential |
| 9. Reinsurance (Meyer and DeTore, 2001) | The activities which need to be carried out to deliver the reinsurance service are decomposed into sets of tasks: problem/opportunity identification, solution development, deal negotiation, administration of current business, facultative underwriting for specific cases | Service process | 1 | Sequential |
| 10. IT services (Miozzo and Grimshaw, 2005) | IT services are implicitly decomposed into: IT infrastructure, help desk, service management, network system management, data centre management, application support and development | Service outcome | 1 | Pooled when offered separately, reciprocal when modules are combined |
| 11. Banking services (four checking account services) (Moon *et al.*, 2009, 2011) | (a) Decomposition into 17 functional modules i.e., "we determine the service functions and service processes". Functional modules: deposit, withdraw, transfer, statement, online account statement, check writing, ATM transactions, online banking with bill payments, telephone banking, online stock trading, optional business economy checking, maintenance fees, additional checking and savings account, loans and lines of credit, service for cashier's check, interest, preferred rates on money markets | Service outcome and process | 2 | (a) Pooled<br>(b) Pooled and sequential |

(*continued*)

| Case | General description of the decomposition, including its boundaries | Decomposition orientation | Decomposition levels | Remaining dependencies between decomposed parts |
|---|---|---|---|---|
| | (b) "Based on the results of the service analysis we can develop activity diagrams for service process modules to identify service processes". Process modules: make a deposit, withdraw money, transfer money, trade stocks, check writing, certify ID, check credit, check balance, make a loan, record transaction, open an account | | | |
| 12. Logistic services (Pekkarinen and Ulkuniemi, 2008) | Subcase A:<br>(a) Decomposition into core services (air and ocean freight services) and "value added services" (order management, supply chain management services, vendor inventory management services, track and trace)<br>(b) Process modules which are necessary to deliver the service modules are defined as: ordering, booking, tracking, custom clearance, billing charges and duties<br>Subcase B:<br>(a) Decomposition into 50 service modules that are not defined in the study<br>(b) Processes are also not described | Service outcome and process | 2 | Subcase A<br>(a) Pooled<br>(b) Sequential<br>Subcase B<br>Could not be determined |
| 13. Professional engineering services (Rahikka *et al.*, 2011) | Decomposition into the different engineering areas: HPAC, electricity, automation, process plant and structure engineering | Service outcome | 1 | Pooled |

(*continued*)

**Table I.**

| Case | General description of the decomposition, including its boundaries | Decomposition orientation | Decomposition levels | Remaining dependencies between decomposed parts |
|---|---|---|---|---|
| 14. Cognitive behaviour therapy (Raune and Law, 2013) | Decomposition into: psycho-education, mood-management, past auditory hallucinations, current persistent distressing auditory hallucinations, current persistent distressing single delusion, current persistent negative symptoms | Service outcome | 1 | Pooled when offered separately, reciprocal when modules are combined |
| 15. Cruise service (Voss and Hsuan, 2009) | (a) The cruise is decomposed into rather "tangible" parts: cabin operations, food and beverages, pools, entertainment, engine room<br>(b) Each module is further decomposed into components that also refer to rather tangible resources. Cabin operations are decomposed into housekeeping, laundry, room service, WIFI connection. Restaurant is decomposed into kitchen, waiters, sommeliers, bus boys. The pool is decomposed into water cleaning, lifeguards, bar, kitchen, tanning products.<br>The engine room is decomposed into maintenance, monitoring, control, cleaning | Service outcome, and resources | 2 | (a) Pooled<br>(b) Pooled |
| 16. Banking service (Voss and Hsuan, 2009) | (a) Decomposed into: credit cards, personal loans, mortgage, investments, insurance, savings, checking account<br>(b) These various service modules can be delivered through different delivery channels: branch, telephone, wireless, internet, digital TV. Further, different interest rates are offered | Service outcome and process | 2 | Pooled |

**Table I.**

uncertainties, the service offerings were then classified as "routine", "semi-routine" or "non-routine". Table II provides an overview of this classification scheme and Table III shows the resulting categorizations of the cases on these variables.

Finally, we performed cross-case analyses to examine whether each of the distinguished decomposition logics was represented in our set of cases and how these logics were related to the modularity type(s) resulting from the decomposition. Here, we created displays to compare the results of our within-case analyses and seek patterns. We did so with an open mind in that patterns other than those anticipated in Section 2 could emerge and we regularly referred back to the underlying information as summarized in Table I.

## 4. Results

### *4.1 Decomposition logics*

In the 18 articles reviewed, we identified 16 cases of service modularity. Below, we present the decomposition logics that had been explicitly or implicitly applied in the 16 cases. We argued that the decomposition logic is based on three steps: setting boundaries; determining decomposition levels; and determining the allowable type(s) of dependencies between the functional parts.

The boundaries of the service systems to be decomposed varied across the cases. In some cases, coordination processes (case 4), management processes (cases 6, 8) or resources (cases 6, 16) were distinguished as modular parts of the service offering, whereas these are not functions that can be delivered to the client. We found that the number of decomposition levels on which functional parts were identified also differed across the cases. The differences in boundary settings and in decomposition levels on which the service offerings were decomposed reflected the term "module" being applied to a wide variety of constituents. Moreover, only three papers (cases 4, 8 and 11) explicitly discussed the decomposition in terms of arguments as to how service parts were assembled into modules in order to minimize the dependencies between modules.

The analysis revealed the presence of four of the main decomposition logics distinguished earlier (Figure 1): single-level process oriented, single-level outcome oriented, multilevel outcome oriented and multilevel combined orientation. The "single-level process-oriented decomposition logic" was applied in two cases (8, 9).

| Input uncertainty | | | |
|---|---|---|---|
| Variety demands | Disposition to participate | Throughput uncertainty | Service routineness |
| Low | Low | Low | Routine |
| Low | Low | Medium | Routine |
| Low | Medium | Low | Routine |
| Medium | Low | Low | Routine |
| Medium | Medium | Low/high | Semi-routine |
| Medium | Low/high | Medium | Semi-routine |
| Low/high | Medium | Medium | Semi-routine |
| Medium | Medium | Medium | Semi-routine |
| Medium | High | High | Non-routine |
| High | Medium | High | Non-routine |
| High | High | Medium | Non-routine |
| High | High | High | Non-routine |

**Table II.** Classification scheme for service routineness

Table III.

| Case | Decomposition logic | Modularity type | Modularization aim (including quotes from original authors) | Input uncertainty: Variety in demands | Input uncertainty: Disposition to participate | Throughput uncertainty | Service routineness |
|---|---|---|---|---|---|---|---|
| 1. Post and package services (Bask *et al.*, 2010) | Multilevel, combined orientation | Component sharing and mix modularities | Provide variety by divergence in "customer interface" and "delivery mode" and increase efficiency by finding "similarities (synergies)" in the production process | Low | Low | Low | Routine |
| 2. Outpatient care for chronic hypertension (Bohmer, 2005) | Single-level, outcome oriented | Cut-to-fit and sectional modularities | Balance customization and standardization | Medium | High | High | Non-routine |
| 3. Lifestyle management programme (Bushe *et al.*, 2008) | Single-level, outcome oriented | Unclear | Unclear | High | Medium | High | Non-routine |
| 4. Psychiatric care (Chorpita *et al.*, 2005) | Multilevel, combined orientation | Component sharing, cut-to-fit and bus modularities | Balance customization and standardization: "unifier the design traditions: a. highly individualized designed in the session and b. highly standardized, designed in a laboratory" | Medium | High | High | Non-routine |
| 5. Homecare for the elderly (De Blok *et al.*, 2010a, b, 2012) | Single-level, outcome oriented | Cut-to-fit and sectional modularities | Provide variety in terms of "demand based care" | High | High | High | Non-routine |
| 6. Restaurant service (Geum *et al.,* 2012) | Multilevel, combined orientation | Unclear | Unclear, although from the use of the "house of quality" it seems that providing variety by means of customization is an important aim | Low | Low | Low | Routine |
| 7. Logistic service (Lin and Pekkarinen, 2011) | Multilevel, combined orientation | Unclear | Provide variety: "establishing linkages between customer requirements and service specifications" […] "providing and | Medium | Medium | Low | Semi-routine |

(*continued*)

| Case | Decomposition logic | Modularity type | Modularization aim (including quotes from original authors) | Input uncertainty: Variety in demands | Input uncertainty: Disposition to participate | Throughput uncertainty | Service routineness |
|---|---|---|---|---|---|---|---|
| | | | managing variety" […] increase customer value/quality: "improve performance" and "to achieve higher customer service levels" | | | | |
| 8. Case management services (Meyer *et al.*, 2007) | Single-level, process oriented | Bus and possibly cut-to-fit modularities | Reduce variety: "create common case management practices and […] process improvement" | High | High | High | Non-routine |
| 9. Reinsurance (Meyer and DeTore, 2001) | Single-level, process oriented | Bus and possibly cut-to-fit modularities | Increase efficiency: ("develop common methods, processes and computer systems") and provide variety (the goal was to assemble and tailor these subsystems to deliver customized services") | High | High | High | Non-routine |
| 10. IT services (Miozzo and Grimshaw, 2005) | Single-level, outcome oriented | Sectional modularity | Unclear | High | High | High | Non-routine |
| 11. Banking services (four checking account services) (Moon *et al.*, 2009, 2011) | Multilevel, combined orientation | Component sharing, mix and sectional modularities | "Increase variety of services" | Low | Low | Low | Routine |
| 12. Logistic services (Pekkarinen and Ulkuniemi, 2008) | Multilevel, combined orientation | Subcase A: component swapping, mix and sectional modularities<br>Subcase B: mix and sectional modularities | Subcase A: Provide customization in a cost efficient manner: i.e., "services may need to be customized" and "build cost efficient solutions by utilizing similarities in customer needs"<br>Subcase B: "Standardization is key strategic priority" | Medium | Medium | Low | Semi-routine |

(*continued*)

**Table III.**

Table III.

| Case | Decomposition logic | Modularity type | Modularization aim (including quotes from original authors) | Input uncertainty: Variety in demands | Input uncertainty: Disposition to participate | Throughput uncertainty | Service routineness |
|---|---|---|---|---|---|---|---|
| 13. Professional engineering and construction management services (Rahikka *et al.*, 2011) | Single-level, outcome oriented | Cut-to-fit and sectional modularities | "Providing variety" and "co-create" value | High | High | High | Non-routine |
| 14. Cognitive behaviour therapy (Raune and Law 2013) | Single-level, outcome oriented | Sectional modularity | Increase efficiency: "greater group therapeutic homogeneity" […] "patients would attending fewer sessions that are not relevant to them, so might be more clinically and financially efficient" | High | High | Medium | Non-routine |
| 15. Cruise service (Voss and Hsuan, 2009) | Multilevel, outcome oriented l | Component sharing, component swapping and sectional modularities | Reduce variety (across multiple sites) "by replicating unique services" | Medium | Medium | Low | Semi-routine |
| 16. Banking service (Voss and Hsuan, 2009) | Multilevel, combined orientation | Component swapping, mix and sectional modularities | Provide variety "the objective was to enable each customer to create a customized banking service, in a manner where the customized service package would have greater benefits than the sum of the individual services if used separately" | Low | Low | Low | Routine |

Both had conceptualized the service offering as a set of sequential internal process stages. The parts reflected intermediate functions, i.e., the different steps taken by the service provider in order to find the best solution for the customer. The functional parts were sequentially dependent and identified on a single relatively high decomposition level.

A "single-level outcome-oriented decomposition logic" was applied in six cases. In these cases the service offering was conceptualized as either a bundle of outcomes (cases 2, 5, 10), as functional areas (13) or as themes (3, 14). In all the cases, the decomposed functional parts were specified on a single decomposition level. The various parts could be offered individually and the decomposition logic is, therefore, characterized by pooled interdependency.

The "multilevel outcome-oriented decomposition logic" was applied in one case (15). Here, the service offering was conceptualized as a service bundle in terms of "what" is delivered. The decomposed parts had been specified on multiple decomposition levels and were predominantly characterized as having pooled dependencies.

The "multilevel combined orientation decomposition logic" was applied in seven cases. Most (1, 7, 11, 12, 16) first decomposed the service offering into different "outcomes" and only then further broke these "outcomes" down into service processes, or process stages or steps. Two cases (4, 6) applied a bottom-up approach, by first specifying the process steps and then combining these into "outcomes". The interdependencies between the outcome-related parts can be characterized as pooled, whereas the process stages can be characterized as having a sequential dependence.

We next analysed the relationship between the decomposition logic (as described above) and the identified modularity types. The data presented in Table IV indicate the relationship between the decomposition logic and the modularity type. In the two cases where we identified a single-level process-oriented decomposition logic (8, 9) we saw cut-to-fit and bus modularity. The six cases that described a single-level outcome-oriented decomposition logic all applied sectional modularity, with three of them also describing cut-to-fit modularity. The only case describing a multilevel outcome-oriented logic (15) combined component sharing, component swapping and sectional modularity types. The seven cases describing a multilevel combined orientation decomposition logic applied a wide mix of modularity types. In three cases (3, 6, 7), no modularity type could be identified.

### *4.2 The relationship between decomposition logic and selected contingencies*

We sought relationships between the decomposition logic and the selected contingencies, i.e., the modularization aim and service routineness. The available results do not show a relationship between the modularization aim and the decomposition logic (see Table IV), although cases aiming at providing variety more often applied an outcome orientation. In three of the cases (3, 6, 10), the modularization aim was not specifically stated.

Finally, we sought relationships between service routineness and the decomposition logic. Each case was categorized on its level of routineness based on their input and throughput uncertainty scores (see Table III, final column). Table IV provides the results of this step in our analyses. Most of the non-routine service offerings applied a single-level decomposition (cases 2, 3, 5,8, 9, 10, 13,14 ). Only in case 4 a multilevel combined orientation had been applied. Whereas in routine and semi-routine service offerings, a multilevel combined orientation was generally applied (cases 1, 6, 7, 11, 12). Case 15 proved an exception, with a multilevel outcome orientation being applied.

**Table IV.** Relationship between decomposition logic and modularity type, modularization aim and service routineness

| Decomposition logic | Modularity type[a] | | | | | | Modularization aim[b] | | | Service routineness | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Component sharing | Component swapping | Mix | Cut-to-fit | Bus | Sectional | Efficiency through lowering costs | Boost variety | Balance variety and efficiency through lowering costs | Routine | Semi-routine | Non-routine |
| Single-level, process-oriented decomposition logic ($n=2$) | | | | 8, 9 | 8, 9 | | 8, 9 | | | | | 8, 9 |
| Single-level, outcome-oriented decomposition logic ($n=6$) | | | | 2, 5, 13 | | 2, 5, 10, 13, 14 | 14 | 5, 13 | 2 | | | 2, 3, 5, 10, 13, 14 |
| Multilevel, outcome-oriented decomposition logic ($n=1$) | 15 | 15 | | | | 15 | 15 | | | | 15 | |
| Multilevel, combined orientation decomposition logic ($n=7$) | 1, 4, 11 | 12A, 16 | 1, 11, 12 (A and B), 16 | 4 | 4 | 11, 12 (A and B), 16 | 12B | 7, 11, 16 | 1, 4, 12A | 1, 6, 11, 16 | 7, 12A, 12B | 4 |

**Notes:** [a]In cases 3, 6 and 7, the modularity types were not clear. [b]In cases 3, 6 and 10 there was insufficient clarity to determine the modularization aim

## 5. Discussion

This systematic review of 16 service modularity cases described in the literature assesses which service decomposition logics have thus far been applied, and how the choice is related to the modularization aims and service routineness. Below, we revisit each of the research questions.

### *5.1 Decomposition logic*

Our first research question was: what decomposition logics, in terms of design choices, are used in decomposing service offerings into modules, and what modularity type(s) result? Our review found that at least four of the six theoretical logics have been applied in practice: single-level process oriented, single-level outcome oriented, multilevel outcome oriented and a multilevel combined outcome and process orientation. Our literature search therefore failed to find documentary evidence of empirical cases involving the multilevel process oriented and single-level combined outcome and process-orientation decomposition logics. A possible explanation for not finding all six theoretically possible decomposition logics is the small number of cases reported in the scientific literature.

In most of the cases we reviewed, the choices underlying the decomposition logic of a modularized service design were barely addressed. However, these are essential design choices because they determine to what extent core modularity principles (Schilling, 2000; Ulrich, 1995) are achieved in a service design: here, modules should have specific functions; be relatively independent of each other; and have standardized interfaces. Through making such design choices the potential added value of modularizing a service will be achieved. Our analysis also shows how the appropriate modularity types depend on these design choices.

### *5.2 Modularization aim and decomposition logic*

Our second research question was: how is the modularization aim related to the service decomposition logic and modularity type(s)? We have not found a straightforward relationship between the modularization aim and the decomposition logic. Those cases that emphasized providing variety to clients did not always apply a different decomposition logic to those that stressed efficiency through lowering costs. However, and in line with our expectations, those that primarily aimed at creating variety for clients always included an outcome orientation. Here, the aim was to match the variety in "what" was delivered with the range of client demands. Moreover, adopting an outcome-oriented decomposition logic makes the variety on offer more transparent to customers than when a process-oriented decomposition is used (Pekkarinen and Ulkuniemi, 2008). Further, it is a matter of degree as to whether one is aiming at providing variety or efficiency (through lowering costs). When a service supply system offers only a very limited range of standard services, modularization can be used to expand the options (Moon *et al.*, 2009, 2011). Conversely, in a hitherto unstructured supply system, where any client wish is answered, modularization serves to rationalize the options (De Blok *et al.*, 2010a).

### *5.3 Service routineness and decomposition logic*

Our third research question was: how is service routineness, in terms of input and throughput uncertainties, related to the decomposition logic and modularity type(s)? Here, we found a clear relationship between service routineness and decomposition logic.

In non-routine service offerings, the single-level process-oriented and single-level outcome-oriented decomposition logics were applied, whereas multilevel logics were mainly applied in routine and semi-routine offerings. We believe this is logical because, in non-routine services, the exact nature of the service needing to be delivered to the client only becomes known as the service delivery progresses. Moreover, as non-routine settings have many reciprocal dependencies (Thompson, 1967), it will be harder to isolate these dependencies within individual modules. As a result, the more fine-grained forms of decomposition will be harder if not impossible to achieve. The commonly applied use of cut-to-fit, bus and sectional modularity types in the non-routine service offerings fit with this explanation. Routine and semi-routine services were decomposed in a hierarchical manner, and module outcomes and processes, and interfaces, were standardized. With such services, it is relatively easy to pre-specify service outcomes and the processes required to deliver them (Bohmer, 2005). Consequently, the common application of component sharing, component swapping and mix modularity types in semi- and in routine service offerings seems appropriate (see Table IV).

## 6. Conclusions

This study contributes to the debate on modular service design through analysing and evaluating which decomposition logics can be identified, and whether these decomposition logics are related to the modularization aims and/or the routineness of the service. Our observation is that argument-building on the design choices underpinning the decomposition of service offerings into modules is scarce in the service modularity literature. In the articles reviewed, we identified four decomposition logics: single-level process oriented, single-level outcome oriented, multilevel outcome oriented and multilevel combined orientation. Although our theoretical framework had distinguished two additional decomposition logics (multilevel process oriented and single-level combined outcome-process oriented), the literature review failed to uncover examples of their use. Furthermore, we found a relationship between the decomposition logic and the modularity types. The aim of the modularization did not seem to explain the decomposition logic; rather, we found that the decomposition logic applied was related to the service routineness.

### *6.1 Theoretical contribution*

The transparent conceptualization of decomposition logics and of the resulting modularity types opens routes for further theoretical development on service modularity. Our review raises awareness of the lack of a conceptual consensus on service modularity design and, more specifically, on the design choices involved in decomposing service offerings into modules. To address this decomposition problem, we have proposed a theoretical framework consisting of three consecutive, albeit partly iterative, design steps: first, define the boundaries of the service offering to be decomposed; second, determine the level(s) on which functional parts will be decomposed; and third, identify the relevant interdependencies and isolate them within (modular) parts. This framework enables modular design choices to be described and analysed at each step. It thereby supports researchers in recognizing fundamental differences between modular service designs when conducting comparative studies. Uniformity in terminology facilitates knowledge development on the effects of different kinds of modular service supply. Moreover, our results offer preliminary insights into how to match decomposition logic and modularity type(s) to the service type on offer.

*6.2 Practical contribution*

A successful modular supply requires an intensive and often time-consuming design process (Baldwin and Clark, 2006). Our proposed framework has practical relevance as it facilitates deliberate design choices when modularizing service supply and a less equivocal application of modularity in service offerings (Rajahonka, 2013; Voss and Hsuan, 2009). Nevertheless, before decomposing, we would suggest first identifying why a service offering should be modularized: what balance to strike between providing variety and lowering costs? Second, the service routineness needs to be considered, as this may have consequences for the appropriate decomposition orientation (outcome, process, combined) and level.

*6.3 Limitations and further research*

A limitation of this research is that, despite an extensive search process, only 18 empirical articles on service modularity were identified for analysis. Moreover, in the majority of these articles, the design choices made were not explicit, and this complicated comparing the decomposition steps. We overcame this limitation by relying on an extensive theoretical framework and an iterative research strategy. Our comparison of reported applications did not include the effects of service modularity. We propose to test whether modularity principles can enable cost savings even in non-routine services. Alongside cost reductions, modular architectures can offer greater transparency to clients on what can be delivered. Providing an overview of modules, and how they can be mixed and matched, could guide the service-specification process (De Blok *et al.*, 2010a). Future studies could, therefore, also examine whether such architectures lower the service-specification costs for the individual client.

**Acknowledgements**

The authors would like to thank Damien Power for reading previous versions of this manuscript and for giving insightful feedback based on his experience in project management. Further, the authors would like to thank the researchers who provided feedback on previous versions of this manuscript during the service modularity workshop 2013 in Hamburg and the EurOMA doctoral seminar 2013 in Dublin. This paper was originally selected by the EurOMA 2013 Special Issue Guest editors, Professor Coughlan and Professor Fynes, to be included in the EurOMA 2013 Special Issue. The revision procedure was managed by the same guest editors.

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