SYSTEM-ORIENTED SERVICE DELIVERY: THE APPLICATION OF SERVICE SYSTEM ENGINEERING TO SERVICE DELIVERY

Research paper

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Abstract

Today, delivery of services is often structured to optimize provider processes and minimize delivery cost. The impact of the resulting delivery quality on the customers is only rarely taken into account. However, its inclusion would open up significant design potential from a "service system engineering" point of view. This is evident, e.g., in industrial maintenance scenarios, where provider costs are frequently minimized, whereas other system-wide costs like failure or consequential costs on the customer side, are neglected.

This work proposes the concept of system-oriented service delivery that creates additional value by delivering service such that total system costs (i.e. the sum of delivery and consequential costs) are minimized. Via the introduction of a monetary re-allocation mechanism between individual participants, any individual disadvantage due to the shift towards system-oriented service delivery can fully be compensated. Therefore, the proposed concept results in a Pareto improvement over today's solutions.

Thus, we apply service system thinking to propose a radically new view to design service delivery. While still a number of issues need to be tackled in practice, the notion of system-oriented service delivery will give rise to new business models for providers and more effective solutions overall.

Keywords: Industrial Maintenance, Service Delivery, Service System, System Theory.

1 Introduction

Service systems and the delivery within these systems have been a key research focus within the past decade. Ostrom et al. (2015) stress both the importance of further research in service delivery and the efficient allocation of service resources to service tasks.

During service delivery, especially in physical services, the provider allocates his delivery resources to service demand. Usually, the provider has multiple delivery alternatives available to choose from, i.e. different allocations of resources to demand. For example, an industrial maintenance provider may have two customers that require immediate repair (service demand), however, has only one technician available (service delivery resource). In this case, the provider may dispatch (i.e. allocate) his technician to one *or* the other customer first, serving the other customer at a later point in time, or vice versa. Thus, in a simple view, the provider has two delivery alternatives to choose from.

Every distinguishable allocation of service delivery resources to service demand is a *service delivery alternative*. The provider faces the associated delivery costs of each delivery alternative. As of now, the provider has a high degree of freedom in resource allocation decision making, which he uses to strengthen his own position, by, for example, keeping his own delivery costs low (Ramaswamy and Banavar, 2008).

This practice, however, has one major drawback: The provider allocates his resources to service demand under incomplete information and—from a systems' viewpoint—conflicting objectives, which results in inefficient resource allocation within the system. For example, the customers may face consequential costs associated with a delayed service delivery. This is especially the case whenever the service provider maintains business relevant infrastructure for the customer, as, for example, in IT outsourcing (Kieninger et al., 2013; Patterson, 2002) or physical asset management (Fox et al., 2008; Salonen and Tabikh, 2016; Wolff and Schmitz, 2017). As our research shows, the provider indirectly decides over his customers' consequential costs, which, however, he does not take into consideration at the time of resource allocation. This is especially relevant as different customers typically have different consequential costs. Therefore, the following scenario is not only possible, but likely: One of two delivery alternatives results in minor delivery cost savings for the provider, however, simultaneously, increases the sum of customers' consequential costs. The other delivery alternative results in slightly higher delivery costs for the provider, but much smaller consequential costs for the customers. In this case, the provider allocates his resources such that his own costs are low at the price of increased costs for his customers, resulting in overall higher total system costs. We argue that this is a systematic resource allocation inefficiency in such scenarios, as the provider has no incentive to allocate his resources such that the total system costs are low.

To address this issue, the objective of this work is to propose a new concept of service resource allocation and service delivery. We propose a general holistic service system concept, in which the provider delivers services following a system-oriented delivery approach. As such, we understand resource allocation and service delivery following service system theory (Spohrer and Maglio, 2010) and service systems engineering principles (Böhmann et al., 2014) by minimizing total system costs, thus including in particular provider's delivery and customers' consequential costs. In addition, we evaluate whether additional capital re-allocation mechanisms between system participants could prevent participants from having a disadvantage in system-oriented service delivery compared to today's delivery approach.

The remainder of this work is structured as follows: First, we introduce relevant related work and lay the foundations in section 2. On this basis, we explain the presented concept. In section 3, we define service systems as understood in this work. Furthermore, we introduce, further explain, and evaluate the concept of system-oriented service delivery. This includes the introduction of a compensation mechanism within system-oriented service delivery such that no service system participant has a disadvantage compared to provider-oriented service delivery. In section 4, the concept is applied to an industrial maintenance illustrative scenario (Peffers et al., 2012), a descriptive evaluation method according to Peffers et al. (2007). The presented concept and its challenges in implementation are discussed in section 5. Finally, in section 6, the work is summarised and limitations as well as future work are highlighted.

2 Fundamentals and Related Work

In this section, we elaborate on service resource allocation and service delivery as well as on service systems and co-creation of value.

2.1 Service Resource Allocation and Service Delivery

Service performance and customer experience heavily depend on the provider's service delivery. In this work, we follow Zeithaml, Berry and Parasuraman's (1988) understanding that service delivery refers to the actual delivery of service, which is further extended by Moorman and Rust (1999) to also include the delivery of products (the firm's goods) to the customer. Therefore, delivery can be of any nature and through any channel (e.g. physical or digital). However, as previously suggested, service delivery capacity is often limited.

Prior to service delivery, the service provider allocates service delivery resources to service demand. Resource allocation deals with the assignment of delivery resources (e.g. personnel, computing power) to service demand (e.g. incident tickets, virtual machines). The allocation of service delivery has been looked at from various domains. Especially in the domain of cloud computing, research on resource allocation is advanced (Beloglazov et al., 2012; Buyya et al., 2008; Wei et al., 2010; Xiao et al., 2013).

Research on physical service delivery resource allocation has received little attention—with the notable exception of traditional scheduling and dispatching problems in the domain of operations research: Here two distinct, yet non-disjoint streams of literature on physical service delivery exist. Whereas the first stream of literature focuses on the mathematical formulation of scheduling/dispatching problems for specific use cases (Banerjee et al., 2011; Cordeau et al., 2010; Hertz et al., 2014; Hill, 1992; Kovacs et al., 2012; Petrakis et al., 2012; Souyris et al., 2013; Verma et al., 2011; Weigel and Cao, 1999), the second stream centres around algorithms to solve formulated scheduling/dispatching problems (Bertels and Fahle, 2006; Cortés et al., 2014; Pillac et al., 2013; Tsang and Voudouris, 1997; Xu and Chiu, 2001). Furthermore, dispatching is an extension to the *Vehicle Routing Problem*, which has been covered and reviewed in Operations Research (Drexl, 2012; Lahyani, Khemakhem and Semet, 2015). Literature in the first stream, however, does not follow system-oriented service delivery. Instead, they aim at optimizing the provider's performance. The second stream only focusses on solving allocation problems independently of the actual use case. Hence, most cases focus on resource allocation for specific use cases and not on generic, use-case independent service delivery approaches.

Furthermore, service delivery has been looked at from a holistic capacity-based perspective. For example, Diao and Heching (2011) present a model for determining the required service capacity in order to deliver the desired service to the customers. Their work is based on an IT outsourcing use case. Thus, the authors take a provider-centric perspective. So (2000) investigates service delivery within networks by presenting a model for determining service prices in a competitive market, in which the customer has the choice between multiple service providers.

Additionally, researchers have elaborated on service delivery innovation. Chen, Tsou and Huang (2009) summarise work on service delivery innovation and identify two streams: First, the introduction of new delivery channels for existing customers, and, second, the introduction of new channels for new customers or new services. The authors build on previous work by Bolton (2003). The focus of service delivery innovation on delivery channels also mirrors Lovelock and Wright's (2002) understanding of service delivery innovation.

2.2 Service Systems and Co-Creation of Value

Due to the growing share of services within the economy of developed countries, services received much attention in research. This development can clearly be seen by the formation of a new interdisciplinary research discipline, namely service science (Spohrer et al., 2007; Maglio and Spohrer, 2008). In addition, the traditional product-focused logic was challenged by more service-centric approaches, as, for example service-dominant logic (Vargo and Lusch, 2004), value co-creation (Vargo, Maglio and Akaka, 2008), service ecosystems (Vargo and Lusch, 2011), and service systems (Spohrer and Maglio, 2010). The concept of service systems is further extended by Maglio et al. (2009) and Spohrer et al. (2008) by defining a framework that explains interactions within or between service systems. Service systems can be of formal or informal nature (Spohrer and Kwan, 2009). In essence, those new concepts evolved on the idea of multiple partners jointly creating value through interaction and sharing of information and knowledge. Especially within the domain of IT, those new concepts quickly evolved and led to a number of scientific publications. Satzger and Kieninger (2011) summarize those new concepts by stating that the goal of this new understanding is that "partners in these systems are supposed to jointly manage the resources […] that allow for maximization of their individual values". Edvardsson, Tronvoll and Gruber (2011) expand the body of literature on service-dominant logic and service systems by a social dimension. In detail, they argue that value does not only depend on context, but also on social aspects, and introduce the term "value-in-social-context". Furthermore, Chandler and Lusch (2015) lay a theoretical foundation and propose a research agenda for exploring actor engagement in service systems over time. Based on service-dominant logic, Wieland et al. (2012) argue that all "economic actors need to be conceptualized as service providing and value creating enterprises since all [..] are essentially doing the same thing as they create value for themselves and others". Furthermore, Böhmann, Leimeister and Möslein (2014) discuss challenges to systematically engineer service systems.

According to Maglio and Spohrer (2008), each relation between one provider and one customer is a service system. Under a service system, we understand participants that drive service interactions between each other such that the outcome meets the participants' expectations (Banerjee et al., 2011; Spohrer et al., 2007). Especially for standardized services (e.g. outsourcing), one provider may have more than one customer and, thus, is part of many different, but yet similar service systems. We refer to the set of individual service systems as service ecosystem. Contractually though, the individual service systems do not influence each other, as service contracts are signed between the provider and one customer individually, however, from a service delivery perspective they do.

3 Service Delivery in Service Systems

Within this section, we first—to set the foundations for the remainder of this work—elaborate on the understanding of *service systems* and *service systems characteristics* that define the given service system. Second, we introduce provider-oriented service delivery, an abstraction from today's practices in service delivery. Additionally, we introduce the concept of system-oriented service delivery. Third, those two delivery approaches are contrasted against each other on a macro and a micro perspective. Fourth, we propose the introduction of a re-allocation mechanism of service system participants' advantages and disadvantages due to the system-oriented delivery approach. Therefore, this section introduces and evaluates the proposed novel concept in service delivery.

3.1 Service System Description

In this work, we understand a service system as a set of participants that interact with each other. For the following, we limit a service system to one provider and (multiple) customer(s). Therefore, the concept of business networks (Holm et al., 1996; Ritter et al., 2004) also applies to the understanding of service systems in this work. However, this work does not focus on the co-creation of value of multiple service providers, and consequently sees a clear distinction between service systems and service value networks (Bitsaki et al., 2008; Blau et al., 2009; Conte et al., 2009; Hamilton, 2004, 2007), which mainly focus on the co-creation of value between multiple providers. However, the application of system-oriented service delivery to value networks is a possible extension of this work.

Furthermore, we want to define our understanding of service environment in this work. In detail, our work addresses any service environment that has the following characteristics:

1) **Star Connection:** The service provider is part of many individual, but yet similar service systems. The customers of the individual service systems do not interact among each other, therefore, making the joint service provider the only point of intersection of the individual service systems within the service environment.
2) **Limited Service Delivery Resources:** The provider has a (short-term) fixed and insufficient service delivery capacity. In other words, the service demand exceeds the delivery resources the provider has available. Furthermore, the service capacity cannot be increased on a short-term basis. Therefore, the provider cannot satisfy the entire demand and has to prioritize some customers. Prioritization directly influences the customers' individual response times (i.e. the time the customer has to wait to receive his service).
3) **Delivery-Dependent Costs:** All participants, thus both the provider and the set of customers, face costs arising from the delivery alternative chosen. During the motivation, we differentiated between delivery and consequential costs. For simplification, however, we do not further dis-

tinguish between the different cost components and refer to them—regardless whether the participant is a customer or provider—as delivery-dependent costs. In case the provider violates any service level agreement, possible penalty costs are included in his delivery-dependent costs. In other words, when talking about delivery-dependent costs, we refer to any variable costs that the participant experiences by the given delivery alternative. Note that those costs only include delivery-dependent variable cost components, as certain cost components are independent of the delivery alternative chosen (e.g. labour wages have to be paid regardless of the delivery option chosen).

4) **Decision Making:** The provider decides which delivery alternative to follow. Through his decision, the service provider determines the delivery-dependent costs of all system participants.

Examples of such service ecosystems are mostly service systems centred around physical services within a B2B market. One prominent group of examples are time-sensitive field agent services, as, for example, industrial maintenance. First, one maintenance provider holds individual contracts with more than one customer, thus forming many individual service systems. Second, his resources are limited, as the number of technicians typically cannot be increased on a short-term basis. Third, the customers experience time-dependent consequential costs due to a machine downtime, which are referred to as indirect costs of downtime (Salonen and Tabikh, 2016). Furthermore, the provider has different delivery alternatives (possible routes) that each trigger different delivery costs. Finally, the provider has the final decision on how to dispatch his technicians (at the risk of additional penalties).

Another example of such service ecosystem is a B2B product distributor in retail. In this example, the product distributor (provider) distributes products to retailers (customers) who then sell it to the end consumers. Obviously, one product distributor distributes the product to multiple retailers, thus forming the star connection between the individual service systems. Now suppose that the demand for a product cannot be fulfilled as there is a limited supply (i.e. limited resources). In this case, each retailer has an interest of selling the product in order to secure profits. However, if the distributor does not deliver the product, the retailer suffers opportunity costs due to lost profits. Furthermore, the distributor bears certain costs associated with the different delivery alternatives. Therefore, customers and provider all face delivery-dependent costs. Finally, however, the distributor has the final decision on whom to deliver, at the price of potential contract penalties.

3.2 Service Delivery Approaches

Previously, we introduced literature on different mathematical optimization models for scheduling or dispatching. Some models require a previously defined task prioritization, while others do not include a prioritization mechanism. However, most of those models optimize from a provider point of view, by, for example, minimizing provider costs, maximizing resource utilization, or maximizing the quantity of service delivered. Those models can be abstracted to a generic provider-oriented service delivery, as the objective function focuses on provider-relevant performance indicators. For simplification and focus on the core argument of this work, we assume that all objective functions can be monetized, and thus be reduced to minimizing the provider's delivery-dependent costs.

Those models show that service delivery of the individual service systems is not independent of each other, as the limited resource capacity is allocated to the joint service system demand. Resource capacity is a short-term exogenous variable that needs to be distributed to the given demand. Demand, however, is a stochastic variable that the provider cannot influence. Therefore, we argue that the individually "contracted" service systems cannot be treated independently and should, consequently, be interpreted as one holistic service system, as depicted in Figure 1 for the case of two customers (A and B) and one service provider (P). In Figure 1, the dotted lines indicate the boundaries of a service system. Such constellations are already known from other service delivery systems, as, for example hospitals, universities, banks, and call centres (Ramaswamy and Banavar, 2008).

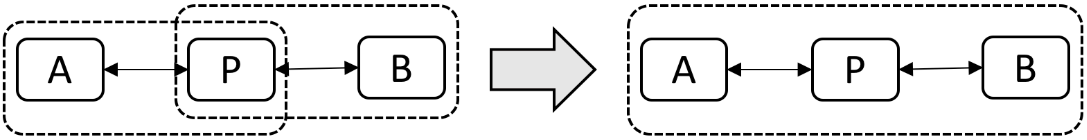

Figure 1. *One Service System with Two Customers and One Provider*

Given this shift towards one holistic service system, we propose the concept of system-oriented service delivery. As such we cluster service delivery approaches that minimize not only the customers' or provider's costs individually, but instead, minimize the total system costs, which is the sum of the customers' and provider's delivery-dependent costs. In other words, we assume the provider knows his set of delivery alternatives. For each alternative, we are able to determine the participants delivery-dependent costs, and, consequentially, can calculate the total system costs. Now, depending on the chosen delivery approach, the utilised delivery alternative can be chosen accordingly. If the service ecosystem follows a provider-oriented delivery approach, the provider would deliver according to the delivery alternative that minimizes his own costs. However, in case that the service ecosystem follows a system-oriented delivery approach, the provider would deliver according to the delivery alternative that minimizes total system costs. Note that the different delivery approaches do not necessarily result in different delivery alternatives.

Figure 2 shows the individual participants costs and delivery decision-relevant cost functions exemplarily for an abstract two-customer-one-provider case—as displayed in Figure 1—for eleven delivery alternatives. Note that individual cost components of participants are modelled as bars for each delivery alternative, whereas the decision-relevant cost functions—the provider cost and total system cost function—are modelled by lines. Within the range of possible delivery alternatives, the different approaches result in different delivery options. Here, delivery alternatives nine and six are the service delivery alternatives chosen when following a provider- and system-oriented delivery approach due to the minimum of the corresponding cost functions within the range of delivery alternatives. We note that the delivery alternative chosen differs between the two delivery approaches.

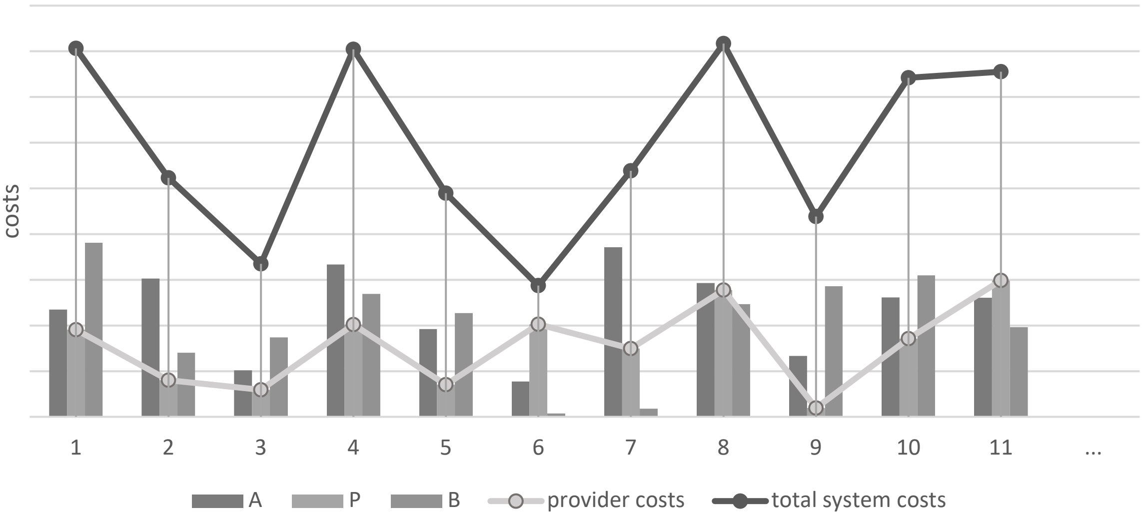

Figure 2. *Exemplary Decision Relevant Cost Functions*

3.3 Comparison of Provider- and System-Oriented Service Delivery

For the following, we define a service system with *n* participants, specifically with *n-1* customers and *one* provider. However, the following argumentation also holds for different numbers of customers and providers within the service system. Each participant has delivery-dependent costs associated with a delivery alternative. Given this setup, we evaluate the benefits of system-oriented service delivery. In order to do so, we compare a delivery alternative chosen under a currently undefined, but yet specific delivery approach with the delivery alternative chosen under a system-oriented delivery approach. The current delivery approach results in service delivery following delivery alternative d_c, which results in individual participants costs $c_{c,i} > 0$ for participant *i*. The total system costs are $c_{c,s} = \sum_{i=1}^{n} c_{c,i} > 0$. This delivery alternative will serve as a baseline.

In the second case, service delivery follows the system-oriented service approach, resulting in service delivery following service alternative d_s. Service alternative d_s introduces individual participants costs $c_{s,i} > 0$ for participant *i* and total system costs are $c_{s,s} = \sum_{i=1}^{n} c_{s,i} > 0$.

Using those two delivery-alternatives, we evaluate the effects of system-oriented service delivery. First, we compare the chosen delivery from a macro perspective, thus only comparing total system costs. Second, we evaluate effects on a participant level. We investigate whether there are participants experiencing an individual advantage or disadvantage from the shift towards system-oriented service delivery compared to the current delivery practice.

Macro Perspective: Per definition, the total costs of the system-oriented approach are smaller or equal to the previous delivery approach. The difference, the system benefit b_s, is easily calculated as shown below.

$$b_s = c_{c,s} - c_{s,s} \geq 0$$

Therefore, from a system perspective, the system-oriented delivery approach is always preferable and dominates the current delivery approach. However, this only reflects the system costs, and does not give any information on the individual participants' benefits of a system-oriented solution. As the system-oriented delivery only changes the allocation of resources to service demand, their ratio between service demand and delivery resources remains equal in the two approaches. Thus, there still are participants that receive delayed service.

Micro Perspective: The benefit b_i of participant *i* can be calculated by taking the difference between the costs in current delivery approaches and system-oriented service delivery, as shown below.

$$b_i = c_{c,i} - c_{s,i}$$

If the individual participant's benefit b_i is greater or smaller than zero, the participant *i* has an advantage or disadvantage from the shift towards system-oriented delivery, respectively. In addition, the total system benefit b_s must be the sum of individual benefits, hence, the following equation holds true. As previously noted, b_s is greater or equal than zero.

$$b_s = \sum_{i=1}^{n} b_i = \sum_{i=1}^{n} (c_{c,i} - c_{s,i}) \geq 0$$

It is possible that a participant has an advantage or disadvantage by the shift towards service-oriented service delivery. In the following, we walk through the possible cases and give a short explanation. First, we assume that the participant is a service provider. In this case, system-oriented service delivery results in a disadvantage if delivery costs are higher due to the new delivery alternative. In the case of field services, this is possible if, for example, the new allocation results in lower resource utilization due to a higher ratio between travel and pure delivery time. On the other hand, the case that the provider has lower delivery costs due to system-oriented service delivery, is possible, if the provider does not follow a pure provider-oriented delivery approach. Second, we assume the participant is a customer. In this case, the system-oriented delivery results in a disadvantage for the customer if his service delivery is delayed, in other words, whenever his priority is lowered. Due to the longer response time his consequential costs increase. On the other hand, the customer has an advantage if his service delivery is accelerated due to his high consequential costs. In this case, his overall consequential costs are lower than in the earlier specified baseline, resulting from his high priority.

3.4 Introduction of a Re-Allocation Method

In the previous subsection, we have seen that some system participants gain an advantage, whereas others suffer a disadvantage by the application of system-oriented service delivery compared with provider-oriented service delivery. However, we have also seen that the total system costs are lower in the case of system-oriented service delivery, therefore achieving a total system benefit (equal or) greater than zero. Following the core concepts of service systems and service systems engineering, we want to re-allocate the participants individual benefits (positive and negative) such that no participant has a disadvantage from the shift towards system-oriented service delivery.

In detail, re-allocation is done by following a three-step process. First, all participants having a positive benefit restrain from it and allocate it towards the service system. Second, the service system's credit is used for a *mandatory compensation* of each participation that has a disadvantage of the system-oriented service delivery. Therefore, from now on, all participants have an *intermediate benefit* of zero. However, the service system still has some credit allocated to it, as the system benefit is greater than zero. Finally, third, the remaining credit represents the overall net benefit created by the system-oriented service delivery and can be shared as desired. For example, an equal distribution between all network participants is possible. The three-step process is exemplarily depicted in Figure 3 for an arbitrarily chosen illustration. The four bar charts indicate the participants' benefit prior, during, and after the application of the re-allocation mechanism. Furthermore, the player *SYSTEM* is added, which collects any financial credit allocated to the system for further sharing with the individual participants.

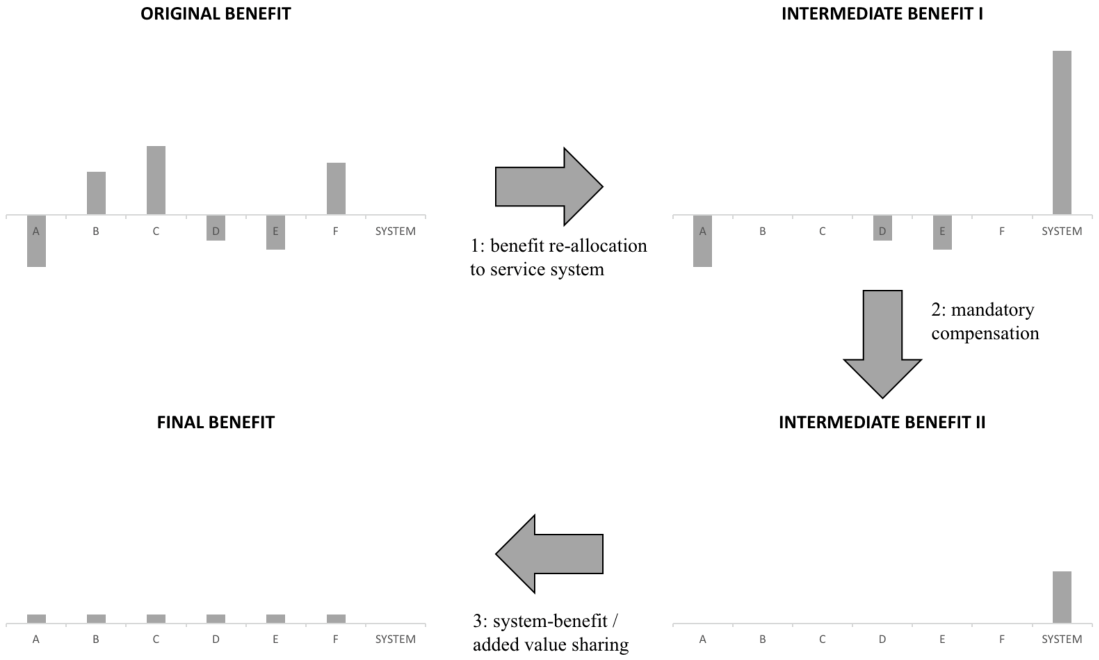

Figure 3. *Exemplary Re-Allocation of Individual Advantages and Disadvantages due to the System-Oriented Delivery Approach*

The four bar charts in Figure 3 show the participant's individual benefits and the credit that the service system has available for further compensations or sharing. The bar chart on the top left side shows the *original benefit* of the network participants solely from the usage of system-oriented service delivery compared to the arbitrary previous solution. In total, there are three participants each experiencing an advantage (B, C, and F) and a disadvantage (A, D, and E). After the first step of the re-allocation mechanism—the transfer of individual advantages towards the system—the participants that originally experienced an advantage no longer have a benefit, in other words, an *intermediate benefit* of zero. Instead, the benefit has been transferred to the system, as indicated by the benefit available to it on the far-right side labelled with *SYSTEM*. The new benefit status is depicted on the top right bar chart. Now, the second step of the re-allocation process, introduces a *mandatory compensation* of those participants that have a negative benefit. The *mandatory compensation* is paid from the system credit, which is—as previously shown—higher than the sum of disadvantages. After the *mandatory compensation*, neither participant has an advantage or disadvantage due to system-oriented service delivery. However, the system still has credit allocated to it (in rare cases, there is no credit left; however, it is impossible that there is a negative credit). This is depicted in the chart labelled as *intermediate benefit II* on the bottom right corner. In the final step, the remaining system credit is distributed between the network participants. In this illustrative case, the credit is distributed equally between all participants, such that all participants have a positive benefit from system-oriented delivery.

Summing up, this section has shown that the system-oriented delivery approach on its own only results in an advantage from the system perspective. This means that the total system costs are lower than in any other delivery approach, which results in a system benefit. The composition of the system benefit of the individual participants' benefits leads to some participants having an advantage, whilst others have a disadvantage by the system-oriented delivery approach compared to the previous delivery approach. However, with the introduction of a benefit re-allocation mechanism, we are able to compensate any participant having a disadvantage through the system-oriented service delivery by re-distributing (positive) benefits. Therefore, the system-oriented delivery approach combined with a re-allocation mechanism results in a Pareto improvement against any other delivery approach. Challenges in its application are addressed in the discussion section below.

4 Towards System-Oriented Service Delivery in Industrial Maintenance

In this section, we transfer the findings from system-oriented service delivery to industrial maintenance. First, we give a short introduction to industrial maintenance, before, second, we apply system-oriented service delivery on a descriptive scenario. Third, challenges in the application of system-oriented service delivery within industrial maintenance are pointed out.

4.1 Fundamentals of Industrial Maintenance

One prominent example of services within the industrial sector is industrial maintenance (Gitzel et al., 2016). Following Geraerds (1984), maintenance includes all activities aimed at keeping or restoring a production asset to its functional state. Today, manufactures report that maintenance costs account for around 28% of their total production costs (Chan et al., 2005), which leads to the perception that efficient maintenance is a competitive advantage over their competitors (Pintelon and Van Puyvelde, 2013).

Traditionally, maintenance was organized as an on-demand business (Wolff and Schmitz, 2017), denoting that the provider would dispatch a technician only after he had been triggered by the customer. Recently, however, customers started demanding long-term maintenance contracts that are closer aligned to their business needs, as already highlighted by multiple researchers (Baines et al., 2007; Van Horenbeek et al., 2012; Huber and Spinler, 2012; Ng et al., 2009). This demand led to the offering of full service (Gitzel et al., 2016; Huber and Spinler, 2012, 2014; Schmitz et al., 2016), availability-based (Datta and Roy, 2010; Erkoyuncu et al., 2014; Ng et al., 2009), and performance-based maintenance contracts (Hypko, Tilebein and Gleich, 2010b; Ng, Ding and Yip, 2013; Selviaridis and Wynstra, 2015). Regardless of contract type, a maintenance provider tries to pursue two opposing operational goals: High profitability and high customer satisfaction, which is usually measured in short-term responsiveness (Klimberg and Van Bennekom, 1997). Furthermore, the provider has the challenging task to assign spatially distributed technicians to spatially distributed tasks, a job usually performed by human dispatchers with little technical support (Vössing, 2017). Being complex on its own, the job is further complicated by the claimed urgency of customers, by, for example, often calling the maintenance provider (Wolff et al., 2018). Overall, dispatchers have been reported to follow unclear rules of decision making (Hill, 1992). The problem of assigning technicians to tasks has been looked at from different perspectives (Kovacs *et al.*, 2012; Petrakis, Hass and Bichler, 2012; Pillac, Guéret and Medaglia, 2013). However, so far, researches have limited their focus on the optimal assignment and on route calculations. To the best of our knowledge, there is no academic work addressing the problem of assigning a priority to a maintenance task. Therefore, the application of system-oriented service delivery marks an important step in the area of industrial maintenance, as it implicitly addresses the question of maintenance task prioritization.

4.2 System-Oriented Service Delivery in Industrial Maintenance

The effects of system-oriented delivery are evaluated with a descriptive evaluation method according to Peffers et al. (2007). In detail, we evaluate system-oriented delivery using an illustrative scenario (Peffers et al., 2012) that reflects a subset of industrial maintenance very well: Four customers (A, B, C, and D) are in need for an immediate repair and the maintenance provider (P) has a single technician available. Hence, we do not take overhaul tasks into account, which is a valid assumption, as many maintenance providers often use dedicated subsets of technicians for the different tasks which are planned independently of each other. Symmetric travel costs between the locations are given as in Table 1. In addition, we assume that the technician is able to fulfil all tasks within one route. One task takes one time period and the consequential costs of customer A, B, C, and D during one time period are 8, 16, 12, 15, respectively. This implicitly assumes time-linear consequential costs, which, however, is a valid simplification as more complex consequential costs only increase the complexity of this work and have no effect on the core idea of this work. The provider's delivery costs are limited to travel costs of the technician only, whereas the technician starts and ends his route at the provider's site P.

		to				
		A	B	C	D	P
from	A	0	10	12	13	16
	B	10	0	15	13	14
	C	12	15	0	10	12
	D	13	13	10	0	9
	P	16	14	12	9	0

Table 1. Travel Cost Matrix

Given four tasks, there are 4! = 24 possible delivery alternatives in total. For each possible delivery alternative, the individual customers' consequential costs, the customers' total consequential cost function, the delivery cost function, and the total system cost function are calculated and shown in Figure 4. Note that the customers' individual consequential costs are indicated as bars, whereas aggregated cost functions are displayed as lines.

Given these delivery alternatives, we note that a provider following a provider-oriented delivery approach delivers according to alternatives (B, A, C, D) and (D, C, A, B), as they result in the lowest provider costs. However, following a system-oriented service delivery strategy, a provider delivers according to delivery alternative (D, B, A, C). Note that the provider-oriented delivery approach results in two possible delivery alternatives which are symmetrical due to the symmetric travel costs. For simplification, we only focus on the latter as the base case, as it results in lower total system costs.

Looking at the given delivery alternatives, namely (D, C, A, B) and (D, B, A, C), we note that the latter results in a system benefit of 8, as the total system costs are decreased accordingly. Therefore, system-oriented service delivery results in an overall system improvement. However, customers A, B, C, D, and provider P have individual benefits of 0, 32, -24, 0, -1, respectively, indicating that customers A and D do not experience any change. This is explainable as both customers remain at the same position within the delivery alternatives and we assume linear response-time dependent costs for the customers. Furthermore, we note that customer B has a benefit of 32, whereas customer C and the provider P have a disadvantage of 24 and 1, respectively. The disadvantage of customer C is caused by the increased response time, whereas the increased costs for the provider are introduced by higher travel costs. The advantage of customer B is due to the earlier service delivery which results in lower response-time dependent costs. Therefore, at this point, service-oriented maintenance does not yield a Pareto improvement compared to provider-oriented maintenance.

Now, we apply the benefit re-allocation mechanism introduced in section 3.4 above. First, participant's advantages are transferred to the system. Thus, the new intermediate benefit of the participants for customers A, B, C, D and provider P are 0, 0, -24, 0, -1 with a total credit of 32 allocated to the system. In the next step, participants with a disadvantage receive their mandatory compensation. After the mandatory compensation, all participants have an intermediate benefit of zero, with an additional system credit of 7. The remaining credit reflects the system benefit and can now be shared as desired. As no participant has a disadvantage compared to the previous solution, regardless of the concrete implementation of system-benefit sharing, the system-oriented delivery approach results in a Pareto improvement. For example, the remaining benefit of seven can be shared evenly between all five participants, thus resulting in final benefits of 1.4 for each participant.

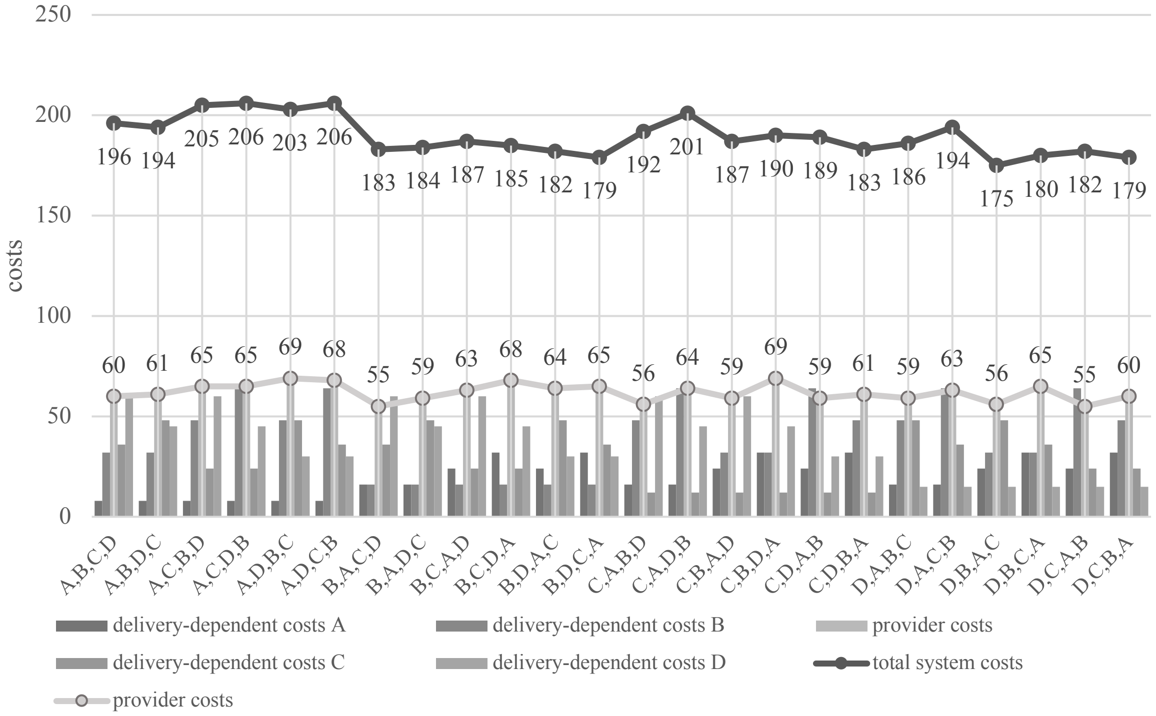

Figure 4. Comparison of delivery options for an industrial maintenance descriptive scenario

5 Discussion of System-Oriented Service Delivery

Even though system-oriented service delivery shows promising results, it has not been applied in practice so far. In the following, we discuss challenges in its implementation and illustrate those for the domain of industrial maintenance.

First, participants must be able to determine their delivery-dependent consequential costs. In the context of industrial maintenance, those are indirect costs of downtime. Unfortunately, according to a study by Crumrine and Post (2006), more than 80% of manufacturers are unable to determine their costs of downtime correctly. Similar results have recently been reported by Salonen and Tabikh (2016). Until today, there is no commonly established approach on estimating costs of downtime during a downtime event. However, some researchers developed simplified models for a broad range of applications (Wolff and Schmitz, 2017), whereas others developed more sophisticated models for specific use cases (Edwards, Holt and Harris, 2002). Also, there is work trying to estimate the costs of downtime ex-post for specific use cases, thus with a diagnostic mind set (Fox, Brammall and Yarlagadda, 2008).

In addition, participants need to share sensitive information with the network (or at least a system coordinator). For example, a service provider needs to provide information of his delivery costs. However, those might be sensitive due to competitive advantage or pricing of the service itself. The same holds true for the customers: Sharing information about their consequential costs allows for implications on their profitability and, for example, in industrial manufacturing, on the manufacturing process. Indeed, information sharing, is a core concept of service systems (Maglio et al., 2009; Maglio and Spohrer, 2008; Spohrer et al., 2007; Spohrer and Maglio, 2010).

Third, another important aspect is the identification of a base case in order to calculate the individual compensations. In this work, we see that system-oriented service delivery outperforms any other possible delivery strategy on a macro scale. In order to prevent a disadvantage for any customer, the disadvantage (and advantage of others) through system-oriented delivery must be calculated. In order to do so, a base case needs to be established first. However, in industrial maintenance, it often is not simple to clearly identify a maintenance provider's delivery and task prioritization strategy (Vössing, 2017), and therefore, the establishment of a base case is a challenging task.

Fourth, a suitable mechanism to deal with the additional created value—the system benefit—needs to be implemented. Especially relevant is the question on who receives which share of the added value. Furthermore, the provider needs to partly re-design his business model, as current models (e.g. premium customers) will no longer be possible. At this point, the mechanism design is very important, as scholars recently pointed out that, for example, bad penalty design has negative impacts on resource and information sharing (Fehrenbacher, 2016).

Fifth, the practical implementation seems to be challenging. For now, we see two different implementation approaches: First, a central entity (e.g. the provider within a one-provider-many-customers-system) can facilitate the entire approach, or second, a decentral, agile system. In the first case, the central entity receives all data, calculates compensations, and compensations may even be facilitated by this central entity to prevent direct cash flows between participants. The second approach aligns closely with dynamic service systems (Maglio et al., 2009; Spohrer et al., 2008), as any participant may join or leave the system at any time. In this approach, decision-making and persistent information storage are a major concern for the applicability of system-oriented service delivery. However, with the recent advantages in the field of distributed ledger technology (DLT), the second approach seems feasible as DLT allows for immutable and trust-building storage of transactions (Beck et al., 2016). According to Seebacher and Schüritz (2017), blockchain—a prominent example for DLT—is a good facilitator for service systems, as blockchain "provides a platform, in which interacting parties can transparently and precisely interact with each other". In the context of this work, an interaction could be, for example, paid compensations between different system participants (as introduced in section 3.4). Costs for providing such infrastructure could most likely be covered by the system net benefit b_S.

6 Conclusion

In this section, we summarise and highlight the contribution of this work. Furthermore, we point out limitations and future work.

6.1 Summary and Contribution

This work lays out a systematic resource allocation inefficiency for a special case of service systems. In detail, these service systems are characterised by one provider that belongs to multiple service systems that are interrelated through the provider's service delivery. In addition, the provider has limited delivery resources, which force him to delay parts of his service delivery. Due to delayed service delivery, customers experience delay-time-dependent consequential costs. In addition, the provider has multiple delivery options to choose from which also bear different costs for the provider (delivery costs).

For the given scenario, this work proposes the concept of a single holistic, orchestrated service system such that a system-oriented service delivery approach is possible. Per definition, system-oriented service delivery minimizes total system costs, thus results in a benefit over any other delivery approach, in other words, a system improvement. However, the benefit in system costs comes at the price of individual participants benefits. In detail, the system benefit results from the sum of individual participants' benefits. Some participants have a positive benefit (i.e. an advantage from the introduction of system-oriented service delivery), whilst others have a negative benefit (i.e. a disadvantage from the introduction of system-oriented service delivery). Therefore, system-oriented service delivery on its own does not result in a Pareto improvement compared to other service delivery approaches.

Furthermore, this work presents a benefit re-allocation mechanism for the system-oriented delivery approach. In detail, the re-allocation process aims at re-allocating the (positive) benefit of individual participants to compensate the participants having a negative benefit due to the introduction of system-oriented service delivery. We refer to the re-allocation as mandatory compensation. Furthermore, this work shows that the sum of participants' advantages (positive benefits) is always greater or equal than the sum of participants' disadvantages (negative benefit). Therefore, all participants having a disadvantage can be fully compensated. The remaining system benefit can be distributed as desired within the service system and system-oriented service delivery—combined with a re-allocation mechanism—results in a Pareto improvement over other service delivery approaches.

By introducing the given concept, this work contributes to the body of knowledge in service delivery, a top research priority in service science according to Ostrom *et al.* (2010, 2015). Furthermore, the presented concept incorporates the core idea of service system engineering (Böhmann et al., 2014). Finally, it contributes to ongoing research within industrial maintenance—a common example of industrial services and an underresearched discipline (Gitzel et al., 2016)—by giving implications of service-oriented service delivery and outlining future challenges for its application.

6.2 Limitations and Future Work

First, the work at hand is highly conceptual. Thus, additional research in this area is necessary to further validate it. For example, detailed specifications and approaches of the re-allocation method must be researched and evaluated further.

Second, this work is limited on single-periodicity and decision-making under full information. In practice, this is often not the case, as, for example, in industrial maintenance (Souyris et al., 2013), where service providers face rapidly changing conditions, as for example, the invoice of a new highly urgent service demand (Vössing, 2017).

Third, implications and evaluation of system-oriented service delivery in industrial maintenance is based on previously determined values (e.g. downtime costs are assumed to be known and deterministic). In practice, these values need to be determined first. Especially the accurate and transparent calculation of customers' consequential costs is challenging (Fox et al., 2008; Kieninger et al., 2013; Patterson, 2002; Salonen and Tabikh, 2016). Furthermore—in case a transparent determination of downtime costs is not possible—the compensation mechanism needs to impede that all customers provide very high consequential costs as they want to be prioritized. For this problem, game-theoretical approaches seem to be promising, by for example, linking the calculation of advantage (and thus also the compensation paid to others), to the provided consequential costs.

Fourth, further research in how to implement system-oriented service delivery in practice is required. For now, we see the work by Seebacher and Maleshkova (2018) as a good starting point, as they present a framework for describing blockchain business networks from both a business and a technical perspective. Furthermore, research on the implementation of the compensation method is required.

Finally, given the domain of industrial maintenance, it is interesting to evaluate how a system-oriented approach performs with different customer contracts, as, for example, predictive maintenance, provider-based business models, availability-guarantees, or fixed response times. All those contracts introduce individual characteristics that will be interesting to evaluate in future work. A promising field of research lies ahead.

References

Baines, T.S., Lightfoot, H.W., Evans, S., Neely, A., Greenough, R., Peppard, J., Roy, R., et al. (2007), "State-of-the-art in product-service systems", *Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture*, Vol. 221 No. 10, pp. 1543–1552.

Banerjee, D., Dasgupta, G. and Desai, N. (2011), “Simulation-based evaluation of dispatching policies in service systems”, *Proceedings of the Winter Simulation Conference*, pp. 779–791.

Beck, R., Czepluch, J.S., Lollike, N. and Malone, S. (2016), “Blockchain–The Gateway to Trust-Free Cryptogrpahic Transactions”, *Proceedings of the 24th European Conference on Information Systems 2016*, pp. 1–14.

Beloglazov, A., Abawajy, J. and Buyya, R. (2012), “Energy-aware resource allocation heuristics for efficient management of data centers for Cloud computing”, *Future Generation Computer Systems*, Vol. 28 No. 5, pp. 755–768.

Bertels, S. and Fahle, T. (2006), “A hybrid setup for a hybrid scenario: combining heuristics for the home health care problem”, *Computers & Operations Research*, Vol. 33 No. 10, pp. 2866–2890.

Bitsaki, M., Danylevych, O., van den Heuvel, W.-J., Koutras, G., Leymann, F., Mancioppi, M., Nikolaou, C., et al. (2008), “An Architecture for Managing the Lifecycle of Business Goals for Partners in a Service Network”, *Proceedings of the 1st European Conference on Towards a Service-Based Internet*, pp. 196–207.

Blau, B., Kramer, J., Conte, T. and Dinther, C. van. (2009), “Service Value Networks”, *2009 IEEE Conference on Commerce and Enterprise Computing*, pp. 194–201.

Böhmann, T., Leimeister, J.M. and Möslein, K. (2014), “Service Systems Engineering”, *Business & Information Systems Engineering*, Vol. 6 No. 2, pp. 73–79.

Bolton, R.N. (2003), “Marketing challenges of e-services”, *Communications of the ACM*, Vol. 46 No. 6, p. 43.

Buyya, R., Yeo, C.S. and Venugopal, S. (2008), “Market-Oriented Cloud Computing: Vision, Hype, and Reality for Delivering IT Services as Computing Utilities”, *2008 10th IEEE International Conference on High Performance Computing and Communications*, pp. 5–13.

Chan, F.T.S., Lau, H.C.W., Ip, R.W.L., Chan, H.K. and Kong, S. (2005), “Implementation of total productive maintenance: A case study”, *International Journal of Production Economics*, Vol. 95 No. 1, pp. 71–94.

Chandler, J.D. and Lusch, R.F. (2015), “Service Systems: A Broadened Framework and Research Agenda on Value Propositions, Engagement, and Service Experience”, *Journal of Service Research*, Vol. 18 No. 1, pp. 6–22.

Chen, J.-S., Tsou, H.T. and Huang, A.Y.-H. (2009), “Service Delivery Innovation: Antecedents and Impact on Firm Performance”, *Journal of Service Research*, Vol. 12 No. 1, pp. 36–55.

Conte, T., Blau, B., Satzger, G. and Dinther, C. (2009), “Enabling Service Networks Through Contribution-Based Value Distribution”, *AMCIS 2009 Proceedings*, pp. 1–9.

Cordeau, J.-F., Laporte, G., Pasin, F. and Ropke, S. (2010), “Scheduling technicians and tasks in a telecommunications company”, *Journal of Scheduling*, Vol. 13 No. 4, pp. 393–409.

Cortés, C.E., Gendreau, M., Rousseau, L.M., Souyris, S. and Weintraub, A. (2014), “Branch-and-price and constraint programming for solving a real-life technician dispatching problem”, *European Journal of Operational Research*, Vol. 238 No. 1, pp. 300–312.

Crumrine, D. and Post, D. (2006), “When true cost of downtime is unknown, bad decisions ensue”, *InTech*, Vol. 53 No. 1, pp. 55–60.

Datta, P.P. and Roy, R. (2010), “Cost modelling techniques for availability type service support contracts: A literature review and empirical study”, *CIRP Journal of Manufacturing Science and Technology*, Vol. 3 No. 2, pp. 142–157.

Diao, Y. and Heching, A. (2011), “Staffing optimization in complex service delivery systems”, *Proceedings of the 7th International Conference on Network and Services Management*, pp. 207–215.

Drexl, M. (2012), “Rich vehicle routing in theory and practice”, *Logistics Research*, Vol. 5 No. 1, pp. 47–63.

Edvardsson, B., Tronvoll, B. and Gruber, T. (2011), “Expanding understanding of service exchange and value co-creation: a social construction approach”, *Journal of the Academy of Marketing Science*, Vol. 39 No. 2, pp. 327–339.

Edwards, D.J., Holt, G.D. and Harris, F.C. (2002), "Predicting downtime costs of tracked hydraulic excavators operating in the UK opencast mining industry", *Construction Management and Economics*, Vol. 20 No. 7, pp. 581–591.

Erkoyuncu, J.A., Roy, R., Shehab, E. and Kutsch, E. (2014), "An innovative uncertainty management framework to support contracting for product-service availability", *Journal of Service Management*, Vol. 25 No. 5, pp. 603–638.

Fehrenbacher, D. (2016), "The Dual Role of Penalty: Service Level Agreement Design and its Effects on Intro-Firm Knowledge Sharing and Commitment of Service Providers", *Proceedings of the 24th European Conference on Information Systems 2016*,pp. 1–17.

Fox, J.P., Brammall, J.R. and Yarlagadda, P.K. (2008), "Determination of the financial impact of machine downtime on the Australia Post large letters sorting process", *9th Global Congress on Manufacturing and Management*, pp. 732–738.

Geraerds, W.M.J. (1984), "The cost of downtime for maintenance : preliminary considerations", *EUT - BDK Report. Dept. of Industrial Engineering and Management Science*, Vol. 11.

Gitzel, R., Schmitz, B., Fromm, H., Isaksson, A. and Setzer, T. (2016), "Industrial Services as a Research Discipline", *Enterprise Modelling and Information Systems Architectures*, Vol. 11 No. 1, pp. 1–22.

Hamilton, J. (2004), "Service value networks: Value, performance and strategy for the services industry", *Journal of Systems Science and Systems Engineering*, Vol. 13 No. 4, pp. 469–489.

Hamilton, J. (2007), "Service value networks: Into practice", *Journal of Systems Science and Systems Engineering*, Vol. 16 No. 4, pp. 414–423.

Hertz, P., Cavalieri, S., Finke, G.R., Duchi, A. and Schonsleben, P. (2014), "A simulation-based decision support system for industrial field service network planning", *SIMULATION*, Vol. 90 No. 1, pp. 69–84.

Hill, A. V. (1992), "An Experimental Comparison of Dispatching Rules for Field Service Support", *Decision Sciences*, Vol. 23 No. 1, pp. 235–249.

Holm, D.B., Eriksson, K. and Johanson, J. (1996), "Business Networks and Cooperation in International Business Relationships", *Journal of International Business Studies*, Vol. 27 No. 5, pp. 1033–1053.

Van Horenbeek, A., Van Ostaeyen, J. and Pintelon, L. (2012), "Maintenance service contracts and business models: A review", *Proceedings of the 17th International Working Seminar on Production Economics,* pp. 1–12.

Huber, S. and Spinler, S. (2012), "Pricing of full-service repair contracts", *European Journal of Operational Research*, Vol. 222 No. 1, pp. 113–121.

Huber, S. and Spinler, S. (2014), "Pricing of Full-Service Repair Contracts with Learning, Optimized Maintenance, and Information Asymmetry", *Decision Sciences*, Vol. 45 No. 4, pp. 791–815.

Hypko, P., Tilebein, M. and Gleich, R. (2010), "Clarifying the concept of performance-based contracting in manufacturing industries", *Journal of Service Management*, Vol. 21 No. 5, pp. 625–655.

Kieninger, A., Berghoff, F., Fromm, H. and Satzger, G. (2013), "Simulation-Based Quantification of Business Impacts Caused by Service Incidents", *Proceedings of the Fourth International Conference on Exploring Service Science*, pp. 170–185.

Klimberg, R.K. and Van Bennekom, F.C. (1997), "Aggregate planning models for field service delivery", *Location Science*, Vol. 5 No. 3, pp. 181–195.

Kovacs, A.A., Parragh, S.N., Doerner, K.F. and Hartl, R.F. (2012), "Adaptive large neighborhood search for service technician routing and scheduling problems", *Journal of Scheduling*, Vol. 15 No. 5, pp. 579–600.

Lahyani, R., Khemakhem, M. and Semet, F. (2015), "Rich vehicle routing problems: From a taxonomy to a definition", *European Journal of Operational Research*, Vol. 241 No. 1, pp. 1–14.

Lovelock, C.H. and Wright, L. (2002), *Principles of Service Marketing and Management*, Prentice Hall, New York.

Maglio, P.P. and Spohrer, J. (2008), "Fundamentals of service science", *Journal of the Academy of Marketing Science*, Vol. 36 No. 1, pp. 18–20.

Maglio, P.P., Vargo, S.L., Caswell, N. and Spohrer, J. (2009), "The service system is the basic abstraction of service science", *Information Systems and E-Business Management*, Vol. 7 No. 4, pp. 395–406.

Moorman, C. and Rust, R.T. (1999), "The Role of Marketing", *Journal of Marketing*, Vol. 63, p. 180.

Ng, I., Ding, D.X. and Yip, N. (2013), "Outcome-based contracts as new business model: The role of partnership and value-driven relational assets", *Industrial Marketing Management*, Vol. 42 No. 5, pp. 730–743.

Ng, I., Maull, R. and Yip, N. (2009), "Outcome-based contracts as a driver for systems thinking and service-dominant logic in service science: Evidence from the defence industry", *European Management Journal*, Vol. 27 No. 6, pp. 377–387.

Ostrom, A.L., Bitner, M.J., Brown, S.W., Burkhard, K.A., Goul, M., Smith-Daniels, V., Demirkan, H., et al. (2010), "Moving Forward and Making a Difference: Research Priorities for the Science of Service", *Journal of Service Research*, Vol. 13 No. 1, pp. 4–36.

Ostrom, A.L., Parasuraman, A., Bowen, D.E., Patrício, L. and Voss, C.A. (2015), "Service Research Priorities in a Rapidly Changing Context", *Journal of Service Research*, Vol. 18 No. 2, pp. 127–159.

Patterson, D. (2002), "A Simple Way to Estimate the Cost of Downtime", *Proceedings of LISA '02: Sixteenth Systems Administration Conference*, pp. 185–188.

Peffers, K., Rothenberger, M., Tuunanen, T. and Vaezi, R. (2012), "Design Science Research Evaluation", *7th International Conference on Design Science Research in Information Systems*, pp. 398–410.

Peffers, K., Tuunanen, T., Rothenberger, M.A. and Chatterjee, S. (2007), "A Design Science Research Methodology for Information Systems Research", *Journal of Management Information Systems*, Vol. 24 No. 3, pp. 45–77.

Petrakis, I., Hass, C. and Bichler, M. (2012), "On the impact of real-time information on field service scheduling", *Decision Support Systems*, Vol. 53 No. 2, pp. 282–293.

Pillac, V., Guéret, C. and Medaglia, A.L. (2013), "A parallel matheuristic for the technician routing and scheduling problem", *Optimization Letters*, Vol. 7 No. 7, pp. 1525–1535.

Pintelon, L. and Van Puyvelde, F. (2013), *Asset Management: The Maintenance Perspective*, Acco.

Ramaswamy, L. and Banavar, G. (2008), "A Formal Model of Service Delivery", *2008 IEEE International Conference on Services Computing*, pp. 517–520.

Ritter, T., Wilkinson, I.F. and Johnston, W.J. (2004), "Managing in complex business networks", *Industrial Marketing Management*, Vol. 33 No. 3, pp. 175–183.

Salonen, A. and Tabikh, M. (2016), "Downtime Costing—Attitudes in Swedish Manufacturing Industry", *Proceedings of the 10th World Congress on Engineering Asset Management (WCEAM 2015)*, pp. 539–544.

Satzger, G. and Kieninger, A. (2011), "Risk-Reward Sharing in IT Service Contracts - A Service System View", *Proceedings of the 44th Hawaii International Conference on System Sciences*, pp. 1–8.

Schmitz, B., Duffort, F. and Satzger, G. (2016), "Managing Uncertainty in Industrial Full Service Contracts: Digital Support for Design and Delivery", *2016 IEEE 18th Conference on Business Informatics (CBI)*, pp. 123–132.

Seebacher, S. and Maleshkova, M. (2018), "A Model-driven Approach for the Description of Blockchain Business Networks", *Proceedings of the 51th Hawaii International Conference on System Sciences*, pp. 3487–3496.

Seebacher, S. and Schüritz, R. (2017), "Blockchain Technology as an Enabler of Service Systems: A Structured Literature Review", *8th International Conference on Exploring Service Science*, pp. 12–23.

Selviaridis, K. and Wynstra, F. (2015), "Performance-based contracting: a literature review and future research directions", *International Journal of Production Research*, Vol. 53 No. 12, pp. 3505–3540.

So, K.C. (2000), "Price and Time Competition for Service Delivery", *Manufacturing & Service Operations Management*, Vol. 2 No. 4, pp. 392–409.

Souyris, S., Cortés, C.E., Ordóñez, F. and Weintraub, A. (2013), "A robust optimization approach to dispatching technicians under stochastic service times", *Optimization Letters*, Vol. 7 No. 7, pp. 1549–1568.

Spohrer, J. and Kwan, S. (2009), “Service Science, Management, Engineering, and Design (SSMED): an Emerging Discipline - Outline and References”, *International Journal of Information Systems in the Service Sector*, Vol. 1 No. 1, pp. 1–31.

Spohrer, J. and Maglio, P. (2010), “Toward a Science of Service Systems”, Handbook of Service Science. Service Science: Research and Innovations in the Service Economy. Springer, Boston, pp. 157–194.

Spohrer, J., Maglio, P.P., Bailey, J. and Gruhl, D. (2007), “Steps toward a science of service systems”, *Computer*, Vol. 40 No. 1, pp. 71–77.

Spohrer, J., Vargo, S.L., Caswell, N. and Maglio, P.P. (2008), “The Service System Is the Basic Abstraction of Service Science”, *Proceedings of the 41st Annual Hawaii International Conference on System Sciences*, pp. 1–10.

Tsang, E. and Voudouris, C. (1997), “Fast local search and guided local search and their application to British Telecom’s workforce scheduling problem”, *Operations Research Letters*, Vol. 20 No. 3, pp. 119–127.

Vargo, S.L. and Lusch, R.F. (2004), “Evolving to a New Dominant Logic for Marketing”, *Journal of Marketing*, Vol. 68 No. 1, pp. 1–17.

Vargo, S.L. and Lusch, R.F. (2011), “It’s all B2B…and beyond: Toward a systems perspective of the market”, *Industrial Marketing Management*, Vol. 40 No. 2, pp. 181–187.

Vargo, S.L., Maglio, P.P. and Akaka, M.A. (2008), “On value and value co-creation: A service systems and service logic perspective”, *European Management Journal*, Vol. 26 No. 3, pp. 145–152.

Verma, A., Desai, N. V., Bhamidipaty, A., Jain, A.N., Nallacherry, J., Roy, S. and Barnes, S. (2011), “Automated Optimal Dispatching of Service Requests”, *2011 Annual SRII Global Conference*, pp. 426–429.

Vössing, M. (2017), “Towards Managing Complexity and Uncertainty in Field Service Technician Planning”, *2017 IEEE 19th Conference on Business Informatics (CBI)*, pp. 312–319.

Wei, G., Vasilakos, A. V, Zheng, Y. and Xiong, N. (2010), “A game-theoretic method of fair resource allocation for cloud computing services”, *The Journal of Supercomputing*, Vol. 54 No. 2, pp. 252–269.

Weigel, D. and Cao, B. (1999), “Applying GIS and OR Techniques to Solve Sears Technician-Dispatching and Home-Delivery Problems”, *Interfaces*, Vol. 29 No. 1, pp. 112–130.

Wieland, H., Polese, F., Vargo, S. and Lusch, R. (2012), “Toward a Service (Eco)Systems Perspective on Value Creation”, *International Journal of Service Science, Management, Engineering and Technology*, Vol. 3 No. 3, pp. 12–24.

Wolff, C. and Schmitz, B. (2017), “Determining Cost-Optimal Availability for Production Equipment using Service Level Engineering”, *2017 IEEE 19th Conference on Business Informatics (CBI)*, pp. 176–185.

Wolff, C., Vössing, M., Schmitz, B. and Fromm, H. (2018), “Towards a Technician Marketplace using Capacity-Based Pricing”, *Proceedings of the 51th Hawaii International Conference on System Sciences*, pp. 1553–1562.

Xiao, Z., Song, W. and Chen, Q. (2013), “Dynamic Resource Allocation Using Virtual Machines for Cloud Computing Environment”, *IEEE Transactions on Parallel and Distributed Systems*, Vol. 24 No. 6, pp. 1107–1117.

Xu, J. and Chiu, S.Y. (2001), “Effective Heuristic Procedures for a Field Technician Scheduling Problem”, *Journal of Heuristics*, Vol. 7 No. 5, pp. 495–509.

Zeithaml, V.A., Berry, L.L. and Parasuraman, A. (1988), “Communication and Control Processes in the Delivery of Service Quality”, *Journal of Marketing*, Vol. 52 No. 2, p. 35–48.