Design of Service Systems under Variability: Research Issues

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Abstract

In service systems, variability is encountered in many components, interfaces, and entities interacting with the system. There could be variations in service system performance across different usage situations and conditions. There could be operator-introduced variations in operating the system, and there could be customer-introduced variability in service operations. Since the specific usage of the service system and the usage conditions can vary, the resultant variations in service performance can impact consumer preferences for and satisfaction with the service system. While some variability has a negative impact on customers, other kinds of variations may be preferred by customers. In designing service systems, one has to understand the sources and types of variability. Any service system that is designed should be robust to these variations – both in system performances and consumer preferences and satisfaction. Achieving the robustness criteria, however, implies consideration of a large number of design criteria across multiple functions – both system design and customer-facing functions. In this paper, we present the factors that need to be considered in service system design which encounter variations not only in usage, but also in operator and customer skill levels, perception of system complexity, preference and satisfaction. We identify the research issues involved and present a general framework to tackle such service system design problems.

1. Introduction

Ever since service and services marketing evolved as a distinct discipline, service variability has played a key role in differentiating services from goods. Extant literature (e.g., Berry 1980) has focused on service performance variability across situations and service encounters and over time arising from equipment, system variations or service employee performance variations, or variations in customers and their interactions (e.g., Kelley et al 1990). Evidently influenced by the developments in the goods and product realm, service variability has always been viewed as something of a negative concept in the design and operational realms of service systems. Thus, following examples from the product and product performance contexts, one of the key objectives in service design and operations has been to reduce variability, control it and eliminate it, if possible, to gain efficiency and improve effectiveness and, thereby, reduce costs of service provision. While this objective is not misplaced, in general, from a performance viewpoint, the zeal to reduce variability in any form is certainly misplaced as it makes the designer, the operator and the manager of service systems blind to the customer-satisfaction-enhancing, revenue-generating opportunities that lie embedded in such variability (Rust and Kannan 2003). The key to eliminating the myopia associated with service variability and thinking of it as strategic opportunity starts with a clear understanding of the variability associated with service systems. This is the central premise of this paper.

In this paper, we have two main objectives. The first objective is to understand the nature and impact of variability in service systems. We first identify the variability that arises in different parts of the service systems – components, equipment, operators and managers, customers, usages and encounters, and all the interfaces between these concepts and entities. The specific questions we focus on include what variances are controllable and what are not, what should be controlled and what should not, impact on these variability on service system operations and robustness of performance, and finally, impact on customer perceptions, choice and re-patronage behavior. The second objective of the paper is to develop a framework for service system design to proactively incorporate consideration of variability in all forms in the service design stage. The paper is structured as follows. In the next section, we discuss variability in service systems in its many forms. In Section 3 we discuss the customer impact of service variability. Section 4 discusses some issues in measuring service variability. In Section 5, we provide the description of the framework and the issues that arise in applying the framework to a service design context. We conclude in Section 6 outlining rich issues for future research.

2. Variability in Service Systems

Most focus of extant literature in variability in service systems has been on customer-introduced variability (see for an overview Frei 2006). Recent thinking is that managing such variability is the biggest challenge of service systems (Sampson and Froehle 2006). In the service operations literature Karmarkar and Pitbladdo (1995) highlight how such variability also introduces uncertainty into the system. The operations literature has focused on queuing systems considering customer arrival rates, distribution, service processing times and distribution and examining their impact on capacity utilization (with resulting impact on costs and revenues) and customer wait times (which impact customer satisfaction). This stream of research implicitly takes into account that service times are functions of system performance and service employee performance. The service management literature has also focused on the same issue albeit with a view to managing the service system, thinking more of it as a production system. Thus, the focus of these efforts has been to reduce customer contacts as much as possible during service operations as a way to improve efficiency (Lovelock 1983). In addition, market based solutions – demand management through pricing variations – have also been suggested as strategies to actively manage customer-introduced variability (Sasser 1976). Bitner et al (1997) focus on training the employees instead as a strategy to counter customer-introduced variability.

Frei (2006) has introduced a typology of customer-introduced variability and a framework for managing customer-introduced variability. Frei explicitly addresses tension between *reduction* of such variability (which has an impact on decreasing operational complexity and thereby operational costs, but which also has, in some cases, the possibility to reduce customer experience) versus *accommodation* of such variability (which enriches customer experience but also has, in some cases, the possibility to lead to complex operations and increased costs). This idea is an extension of contingent approach seen in queuing system. Frei (2006) introduces a typology of customer-introduced variability and applies the approach to each phase of the typology. Thus, customer-introduced variability is classified as those occurring in the different phases of (1) arrivals of customers, (2) requests made by customers, (3) capability of customers with respect to their expected involvement, (4) effort customers are willing to exert, and (5) subjective preference of customers for how service should be delivered. Frei also makes the distinction between classic reduction (where customer utility is somewhat negatively compromised) and uncompromised reduction (where utility is not compromised), and between classic accommodation (where service costs tend to increase) versus low-cost accommodation. Thus, in managing customer arrival variability, an uncompromised reduction may involve creation of complementary demand or outsourcing customer contact, while a classic reduction may involve requiring customer reservations, or off-peak pricing or limited service availability. While class accommodation techniques may involve slack labor or flexible labor, low-cost accommodation may involve low-cost labor or automation of self-service options.

There is significant variability in service systems that cannot be ascribed to customers. A key factor responsible for service system performance variability is employees of the service system. Employees can be heterogeneous in their skill levels, service aptitudes, and so on. Another source of variability is due to equipment performance as a function of ambient conditions, operating conditions of the service system, geographical markets, etc. For example, mobile phone services vary across geography, network service system performance can be affected by local climate – heat and weather related events. Thus, significant variation can be introduced within the system that can be attributed to the one or more components of the system. Over and above these variations, other sources of variability include interfaces between system components and customers (some of which were captured in the above discussion).

Among many of the sources of variability identified above, some are *controllable variations* while others are not. As already discussed, various phases of customer-introduced variability can be controlled through reduction approaches. Some of the variations cannot be controlled easily –where they use their cell phone, for example, but customers can be persuaded to compromise. For many of the customer-introduced variability, reduction is always a possibility – it is just a question how much loss in customer-utility are customers willing to tolerate before switching to competitors as a result of the reduction strategies. Among the sources of variability within the system arising due to one or more of its components, some of them could be controlled. For example, variations in employee service performance can be controlled through appropriate training. Variability in equipment performance can likewise be controlled with better and more reliable designs. Variability in cell phone service across geographical regions can be reduced by building more cell towers. However, there are certain variability in operations conditions, ambient temperature, geography induced variations that are beyond the control of service system. For example, when AAA services are called on to repair an automobile on a road they cannot control the operating conditions under which they will be working on the repair job. Such sources of variability are not under the designer's control and thus will have to be explicitly accommodated in the design.

Are all forms of service system variability necessarily undesirable? Do they have to be eliminated or reduced or controlled? If we view the variability as a negative deviation from intended service quality level, then reduction is a key objective. But, it is important to understand how the source of this deviation. For example, if there is a variation in system performance that impacts service quality negatively as compared to what was designed for, then eliminating such variability will be useful. But can we extend the same analogy to the customer-introduced variability? Can a bank refuse to service a customer who is not organized and takes an unusually long time to complete his/her transaction and thus hold up other customers in the queue? Here, the reduction and accommodation strategies proposed by Frei may come in very useful in dealing with what variability should be reduced and what should be accommodated. We have a different philosophy here as we explain below.

Compared to many extant approaches in service literature, Frei's approach (and the queuing literature) explicitly takes into the tension between improving customer experience and increasing the operational efficiency. Yet, we contend the approaches have an significant emphasis on the cost and operations side of the equation – thus, the word "accommodation" itself is a tacit admission that customer-introduced variability is inherently troublesome for operational efficiency, and since it cannot be eliminated or reduced, it has to be (grudgingly) accommodated. This thinking permeates the design process of service systems and hence the limitless opportunities afforded by customer-introduced variability for revenue/profit generation is frittered away through variability-reduction strategies. Variations such as these might provide insights for radical design developments that can lead to paradigm shifts in service system impact. Thus, we argue that customer-introduced variability requires different treatment in the design process – one that would take advantage of the revenue expansion route to service design rather than emphasize the cost reduction approaches (Rust et al 2001, Rust and Kannan 2003). Accordingly the framework we propose will treat customer-introduced variability as a market opportunity and design service systems proactively for variability. This idea is further strengthened when we examine the customer impact of variability.

3. Customer Impact of Variability

It is well recognized that service system performance variability can have a significant impact on customers' perceptions of service quality (McQuitty et al 2005). Service system performance variability affects the way in which service meets or fails to meet customer expectations. If the variance is a negative deviation from the intended service quality level (and the expected quality level of the customer), then customers may be dissatisfied with their service experience. If it meets the expectation then customer are satisfied. Thus, customers tend to equate variability with risk and uncertainty, which has a negative impact on the service evaluations. Extant literature in service expectation and customer satisfaction has clearly shown that variability impacts overall satisfaction, perceived quality, image and future expectations (e.g., Brown et al 1996). Service system variability also has a negative impact on service purchase and re-patronage intentions, perceptions of service quality and value.

The level of customer expectations, which play a critical role in determining overall customer satisfaction, also has a significant impact on how variability in performance is processed by customers. Meyer (1981) shows that attribute variance decreases choice probability, especially for services perceived to be of high quality. This indicates that variability of service performance interacts with the mean level of performance that a customer expects from a service provider.

Since we have focused our attention mainly on service system performance, does it mean that these findings do not apply to customer-introduced variability? Where does customer-introduced variability play a role in this? It is clear that customer-introduced variability is an important factor in service system performance deterioration. However, customers evaluate service system performance from their own frame of reference. This means that they may not take the variability introduced by customers as an excuse for variability in service performance by the service provider. Thus, if a customer is standing in a line for a cup of coffee at Starbucks and sees that customer ahead of him ordering a designer drink that takes a longer service time, he is not going to excuse the long wait time, attributing it to the customer ahead of him. Rather, he is likely to be critical of the design of the service system (not enough baristas to provide service) and penalize the service provider for that. On the other hand, a flexible handling of different orders of customers in a quick manner may enhance the customer's perception of flexibility of the service provider and customizing the service for him. The crux of this discussion is as follows: if customer-introduced variability is not managed well by the service provider, then the overall satisfaction is negatively impacted. However, if it managed well by the service provider, customers' perception of the flexibility and customization skill of the service provider is likely to be highly positive and a source of sustained competitive advantage. This again emphasizes the central premise of the paper that customer-introduced variability is a strategic opportunity for significant revenue growth.

4. Measuring Variability

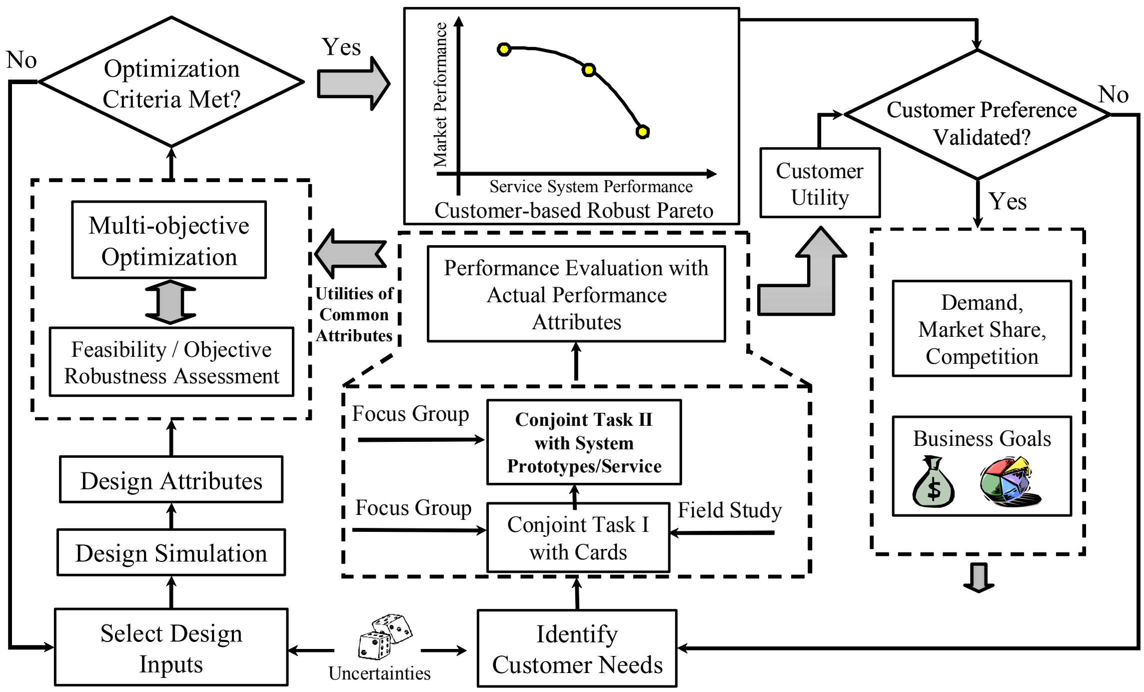
Given the preceding discussion on identifying service system variability, strategies for reducing, accommodating, or treating them as revenue opportunities has made it quite obvious that such variability should be measured. If customer-introduced is measured appropriately, then it can be proactively used in designing systems that convert the opportunity presented by such variability. How does this translate in practice? It implies that measurements be made of service expectations across all consumers targeted. Conjoint models measuring the attribute importance values in the service context (e.g., Danaher 1997) should not only include mean levels of attributes but also variances in their attributes and the interaction between mean levels and variance levels. Measurements should be made of the impact of variability on customer perceptions and choice. Such measurements will allow setting appropriate targets for reduction, accommodation and revenue expansion targets. In addition to measuring customer-introduced variability, variability of service system component performance – performances of employees, equipment, and such – should be made, whether they are controllable or uncontrollable variability. In some cases, uncontrollable variability can be specified in terms of upper and lower bounds – that an interval of variation which is beyond the control of the designer, but nevertheless possible to measure. This measurement will form the starting point for our proposed design framework.

5. Design Framework

The main focus of the service system design framework that we have suggested is as follows: instead of managing all forms of service system variability as an after-thought, we design the system explicitly to reduce some components of the variance and take advantage of some of the main customer-introduced variability in a design process that cuts across the different disciplines involved in the design process. Our proposed framework integrates service operations/processes with service marketing aspects and the customer-facing attribute design. Application of the framework is intended to result in (1) robust service systems – robust from both operational and marketing perspectives, (2) focusing on explicitly specifying the variability and its impact on customer facing attributes and customers, (3) consideration of impact of variability in customer-facing attributes on preferences and choice, and (3) an integration of all the above factors in the service design process.

While our framework is inspired by our previous experiences in the product design realm (Luo et al 2005), it provides us with clear directions on how the service design process should unfold.

Figure 1: Overall Framework



A schematic diagram of the service design framework is presented above. The diagram is to be read from bottom-up with two starting points – a focus on the customers in the right-hand block at the bottom – where their needs, preferences and expectations are identified first, and a starting point at the left with system design where design input is selected. We will explain this framework with an example of an oil-change service station being designed from scratch. In the context of this example, selecting the design inputs would involve the appropriate oil-change equipment and process that will be laid on the bay of the service station. There could be many different equipment and components that could be selected – each combination could result in the design attributes that will define the service. For example, with a particular equipment and process combination the service time for an oil change on a standard automobile might be 10 minutes, whereas another combination might result in a 12 minute service time. The mapping of the design inputs into design attributes is accomplished through design simulation or testing or specifications, etc. Our design process shows that this mapping between what the designers selects as design input has a significant impact on the design attributes or the design performance.

On the left side of the diagram, customer-introduced variability is measured. This could be the type of automobiles that they drive – big, small or medium size. This variability will have an impact on the design attributes. Customers' preferences for the various attributes that up the service are measured ensuring that the variability levels for the mean levels of the attributes are incorporated in the conjoint study. Customers may work with prototype service systems and may go through multiple measurement tasks – all to ensure that the variability that we discussed in the previous sections are appropriately measured.

It is important to note that the customer-facing attributes and the design attributes generated from the design selection of inputs are rationalized in the multi-objective optimization and feasibility and robustness assessment block on the left. Since we measure customer-introduced variability explicitly, its impact on the serviced system performance measures is explicitly measured. Similarly, we also measure the impact of uncontrollable variability on the design attributes. For example, the ambient temperature in the service shop may affect service times. Or the arrival rates of customers and system run time may affect the performance of the service system. Whatever be the scenario, these are evaluated in this block.

Figure 2: Feasibility Assessment

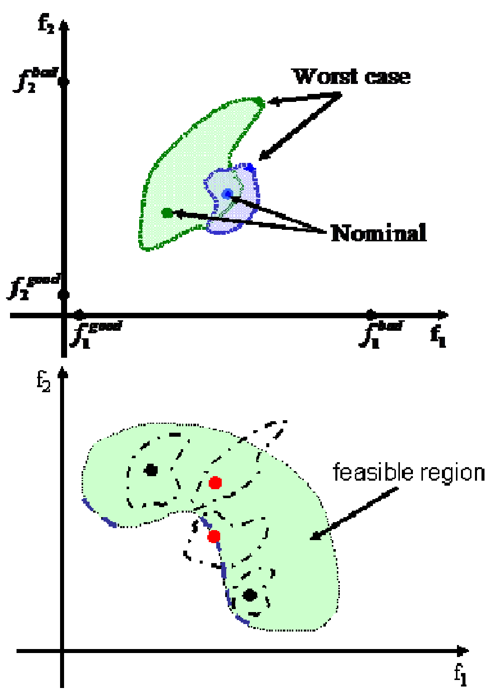


Figure 2 provides a schematic representation of the feasibility assessment process. The top figure in Figure 2 shows the impact of variability on design attributes. Assume that the two axes are service time for an oil-change and oil-waste generated in the process. The objective is to minimize both these design attributes in selecting the input design variables. However, these design attributes can be impacted by variability such as the type of automobiles that customers drive. Depending on this variation, service times could be affected and so will oil waste amount. Thus, while the nominal performance of two competing design options can be represented by the dots in the top figure, their value can vary all over the regions indicated above. In fact, the design which has a better nominal value performs poorly under the worst case scenario. If we were to specify the feasible region for service system performance, some of the design options can become infeasible under variability. Thus, explicitly considering all forms of variability in the system in selecting a service system design can help in designing a system that will remain feasible under all variability and thus be robust – and provide the flexibility and customization that customers might value greatly.

The feasibility conditions can include reduction and accommodation criteria. Setting these conditions too tight might mean a narrow market focus. Another important feature of our framework is also that it explicitly accounts for competition and competitive positioning in evaluating the impact of a chosen design on customer relative utilities and market shares. Thus, the framework will help designers to understand overall impact of the design being evaluated at the market level. At the left hand top block of Figure 1, an option is provided for optimization if the design input is very large to evaluate on a case-by-case basis.

The application of the framework finally results in customer-based robust Pareto solutions where design solutions are generated that lie on the Pareto frontier of service system performance and market performance (in terms of the revenue or profit generated). This takes into account the existing competition, so the service system designers can evaluate the market performance versus the service system performance in terms of the relative positioning vis-à-vis competition. The framework can be extended to design a service line rather than just one specific system.

The advantages of the framework are fairly obvious from Figure 1. The framework forces all disciplines – marketing, operations, and design - to take a systems perspective and work together to optimize the whole service system design. It is not a piece-meal approach where service operations might be viewing the whole design process from a cost reduction and efficiency viewpoint. It also does not result in a situation where service marketing is designing the services from the viewpoint of what the market wants to hear without taking into account the operational realities and the impact of all forms of variability. The framework is also not meant to be a substitute for all customer and process oriented research that may be going on in the service firm. Rather those activities are used as building blocks in creating the processes outlined in Figure 1. The framework not only explicitly considers all forms of variability but it considers the impact on the selection of design inputs, impact on customer preferences and rolls it all up in the overall optimal selection of design inputs.

6. Conclusions

Our overall objective in this paper was to identify the different forms of variability in service system contexts, understand the nature of these forms of variability, whether they are controllable or uncontrollable, and whether a reduction or revenue generating strategy is necessitated depending on the specific form of variability. We also argued that extant design and operations literature is too focused on cost reduction and efficiency and tended to view customer-introduced variability as something to be accommodated rather than welcomed as a revenue expansion opportunity. We then presented a framework that explicitly considers all forms variability and attempts to view service system design from a revenue expansion perspective.

From the viewpoint of service system design, our paper is meant to be seen as a more provocative piece with an intention to raise more questions than it can answer. Certainly, many questions can be asked regarding the specific blocks of Figure 1. What is design simulation? Where is the data coming for the simulation? We agree that such data has to be built over time as design inputs are put together and design attributes (system performance) measured. In some domains, such testing is already very common (such as in information and network systems) and systems exist to perform such simulations. In other contexts, such as hospitality industry or law services, such data may not exist at this point and may have to be built over time. What is important in Figure 1 is the identification of the critical pieces of information that is needed in order to consider variability systematically in the design process. If they do not exist at this point, then the service firm can make it is a priority to gather such information. The framework clearly provides a starting point for such an exercise. While it is undeniable that the framework is described at a general level, the challenge is to apply the overall framework to many service situations and provide concrete examples of what the framework can lead to. This is something we are currently working on as an implementation.

Finally, our paper is making a call to view the challenge of variability not as a problem to be solved, reduced, contained, or eliminated, but view it as an opportunity to make service system break-through. In this the paper resonates strongly with the recent call of IBM, HP, and Sun and other service-oriented firms to unite under the common goal of Service Science Management and Engineering (SSME) initiatives (Spohrer et al 2007), as the framework clearly integrates the management of service with the engineering of it using the science of variability measurement. In this, we hope we have made a small contribution in the right direction.

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