airiti press

GPN 2007800019
ISSN 1018-1393
9 771018 139006

MIS REVIEW Volume:15 Number:2 March 2010

MIS REVIEW
An International Journal

Vol.15 No.2 March 2010

MIS Review **Vol. 15, No. 2** Published in March 2010

Publisher: Eugenia Y. Huang

Published by: Airiti Press Inc. & National Chengchi University, Department of Management Information Systems

Editor-in-Chief: Eldon Y. Li

Executive Editor: Tsang-Hsiung Lee

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Printed by: Sincere Digital Printing, Co.

Cover Designer: Thomes Chen

Typesetting: Li-Yu Chen

Publication Office:

National Chengchi University, Department of Management Information Systems
No.64, Sec. 2, ZhiNan Rd., Wenshan District, Taipei City 116, Taiwan

Airiti Press Inc.
18F., No.80, Sec. 1, Chenggong Rd., Yonghe City, Taipei 234, Taiwan

e-Journal: http://www.airitilibary.com

ISSN: 1018-1393

GPN: 2007800019

Printed in Taiwan

Editorial Board

Editor's Introduction

In this issue, we proudly present to you the special issue on service science edited by Prof. Soe-Tsyr Yuan, a well-known scholar who has been very active in service science research for the past decade. In this special issue three papers are included, covering the topics of service transfer, service mindset, and service delivery. Beside this special issue, there is an additional research paper by Praveen Ranjan Srivastava et al. In their paper, entitled "Non Homogenous Poisson Process Model for Optimal Software Testing using Fault Tolerance," they propose a way to prioritize several modules of a software product and calculate optimal time and cost for testing based on non homogenous Poisson process. They also try to figure out whether the software could be released or not, after testing within a given time and cost. The authors advise that sometimes it is more profitable for an organization to release software even if it is not completely tested, because of limited time and resources.

We would like to give our sincere appreciation to Prof. Soe-Tyse Yuan for her excellent editorial effort in completing the special issue on service science. Special thanks also go to the authors and the reviewers for their collaborative effort to make this issue possible. Finally, to our loyal readers around the world, we hope you enjoy reading and benefit from the contents of the papers.

Dr. Eldon Y. Li
Editor-in-Chief and University Chair Professor

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Spring 2010

Editorial: Special Issue on Service Science

Except those in the goods-producing sectors (agriculture, mining, construction, and manufacturing), the service sector encompasses all other industries including transportation, logistics, communication, wholesale and retail, trade, education, finance, insurance, real estate, healthcare, postal operations, government, and a variety of public services. The service industry has grown to dominate developed economies. Although the services, in their many different guises, have permeated modern economies, there is no clear understanding on *how to achieve systematic services innovation*, *how to define and measure service innovation*, *how to engineer customer psychology into service encounter and system design*, *how to control the adaptation of services in light of different forms of customer variability*, *how to develop innovated service features with IT*, *etc*. To help move this new field forward in Services Science, this special issue will serve as an initiative to achieve the multiple objectives in the context of the IS discipline together with the other cross-domain disciplines. The overall goal is to establish services-oriented research with foundational and interdisciplinary papers published within the MIS Review. This special issue includes three research papers. As follows show the summaries of the three papers.

Aleda V. Roth and Jeff Shockley in their paper "A Multidisciplinary Design Model for New Service Offering Transfers and Internal Integration in Retail Chain Services" examines the transfer of information and know-how in the innovation cycle through an organizational design system. This system leverages ICT to promote internal integration practices and operational consensus in retail chain services. This paper also offers a multidisciplinary framework of internal integration and several researchable propositions for future studies of integration in service science by incorporating insights from diverse areas including knowledge management, supply chain, and service operations theory.

Steven Alter in his paper "Applying a Service Mindset When Thinking and Communicating about Systems and Projects" explains four principles underlying a service mindset for systematically thinking and communicating about service systems and projects. The principles combine ideas from disciplines including information systems, strategy, marketing, and service operations. These principles then lead to three frameworks for thinking, communicating and innovating about IT-reliant systems, and these frameworks subsequently imply tools that can support business-oriented description and analysis of IT-reliant systems in organizations.

Wei-Feng Tung and Soe-Tysr Yuan in their paper "A Symbiosis-Based Value Co-Creation Framework for Service Delivery Design" presents a framework for service delivery system design as a means-end tool based on the ecological perspective for modeling, designing, developing and measuring the service systems (e-service) which can

fulfill (semi-)automated value co-creation between the service providers and the customers within service delivery. This framework also proposes a blueprint to identify a variety of intelligent service delivery system designs.

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Acknowledgement

The guest editor of this special issue would like to thank all the authors for their high-quality, original contributions from the IS/IT and interdisciplinary perspectives.

About the guest editor

Soe-Tsyr Yuan received her Ph.D. degree in Computer Science from Oregon State University in 1994. She is a Professor of MIS Department and Director of Service Science Research Center at College of Commerce in National Chengchi University. Her research interests include Service Science, Management and Engineering, Service System Design, Service-Oriented Computing, Electronic and Mobile Commerce, Strategic Information Systems and Multi-agent Systems and Data Mining. She has been on the editorial boards for several international journals including *International Journal of Web Services Research*, *Service Oriented Computing and Applications*, *International Journal of E-Business Research*, *International Journal of Information Systems and Management*, etc.

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Content

Research Articles

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A Multidisciplinary Design Model for New Service Offering Transfers and Internal Integration in Retail Chain Services

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ABSTRACT: *Service science proposes a multidisciplinary approach to analyzing services. Models of internal integration have been studied extensively in operations management and organizational design research. However, there are few applications of these multidisciplinary models to study retail chain service environments, where knowledge transfer of a new service offering must be communicated and transferred to remote service operators who are primarily responsible for effective execution. This paper explores how to mitigate new service offering 'stickiness' through an organizational design system that leverages information and communication technologies to promote internal integration practices and operational consensus in retail chain services. Furthermore, this paper offers a multidisciplinary framework of internal integration and several researchable propositions to advance scholarly service science research that will influence retail service practice.*

KEYWORDS: *Service Science, Retail Design Strategy, Service Operations Strategy, New Service Development.*

1. Introduction

This paper examines the successful knowledge-transfer and replication of new service offerings in retail chain services (RCS), using a multidisciplinary lens advocated by the emerging view of service science (Spohrer et al., 2007). Following Menor and Roth (2007, p. 826), we define a new service[1] in terms of the service concept bundle and/or delivery process, "as an offering not previously available to the firm's customers that results from either an addition to the current mix of services or from changes made to the delivery process." RCS organization "consists of multiple centrally-owned and, to some degree, managed outlets with the same name that sell similar merchandise (or services), have similar appearance, and follow similar business procedures" (Ghosh, 1990, p. 39). RCS may be centrally governed by a corporate office or support center, or may be part of a franchise network, and managing them requires a high degree of internal and external integration. Much of the American service landscape is dominated by RCS, including up to 30% of

1 In this research, "new service offerings," "new services," and "service innovations" are used interchangeably.

annual U.S. domestic GDP (Bureau of Economic Analysis, June 2009), and RCS are on the rise internationally.

Our research proposed here revolves around the central question: How can RCS organizations instantiate new service offerings throughout their organizational design systems? We note that the ability to form and replicate new services is an important theme in service science. From a review of the related literature in internal integration and service strategy, we develop a multidisciplinary framework, as depicted in Figure 1, and offer a series of propositions and research questions that will set the stage for a broader service science research agenda on retail service chain innovation strategies. Our multidisciplinary organizational design model is an adaptation of both a service strategy (e.g., Roth and Menor, 2002; Voss, Roth, and Chase, 2008) and a supply chain (Pagell, 2004) organizational model of internal integration, which are applied to support the use of technology in RCS. Each construct in the model -- *organizational dialogue, new concept development, structural cooperation, and measurement competence*--refers to the dyadic relationship between local chain outlet operators and the common owner (replicator). The solid lines in the framework indicate the direct information transfers that might be most effectively achieved using information and communication technologies (ICT) (Pagell, 2004). The dotted lines represent the feedback loops among integrative practices, which are bi-directional and mutually reinforcing.

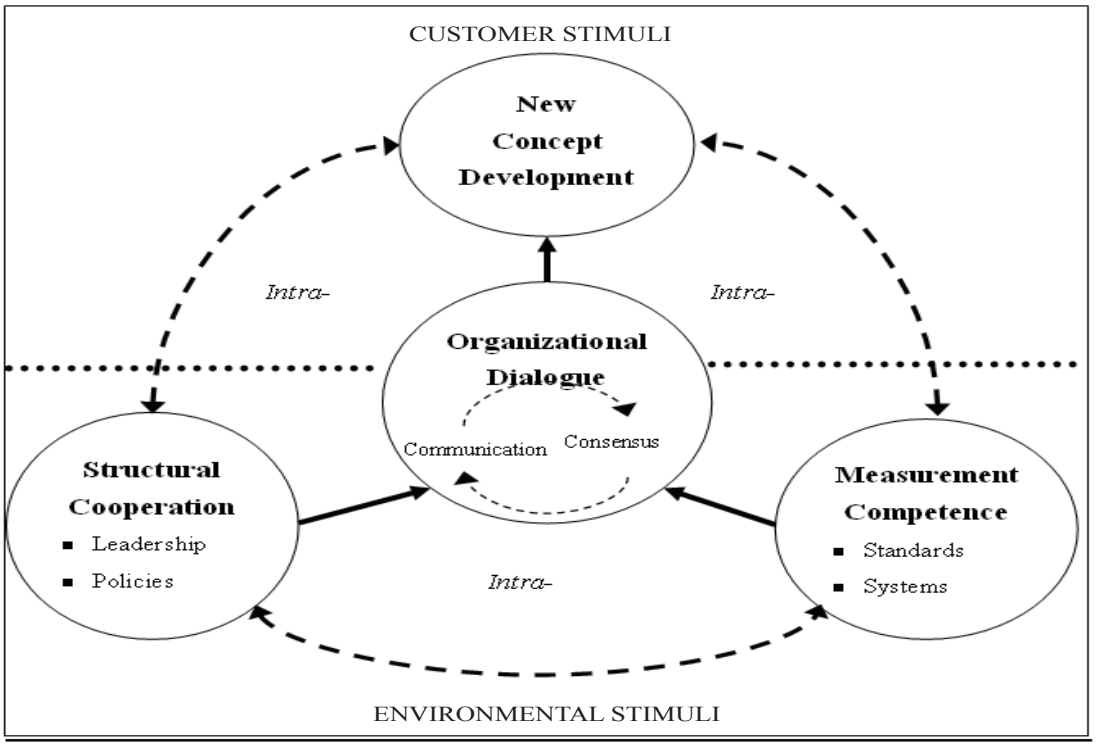

Figure 1 Multidisciplinary Design Model of Internal Integration in RCS

Service innovations are clearly important to build or maintain competitive advantage (Roth and Menor, 2008); however, little is known about their diffusion in a retail chain. In RCS, successful new services are associated with the duplication of the innovations across geographically dispersed locations, and iterative and continuous two-way information sharing is imperative. It is often the case that a multi-site, retail chain innovation strategy is a multi-country endeavor, which requires deliberate adaptation to the local culture (Voss et al., 2004; Weng, Roth, and Miller, 2009). To promote effective new service concept replication, automation, and economies of scale in these dynamic retail service environments, service scientists would consider how models and frameworks from multiple disciplines might be used to explain the interactions of human-server, policy, culture, and job design strategies with the ICT that is being used (Roth and Menor, 2003; ifM and IBM, 2007; Hefley and Murphy, 2008; Shockley, 2009).

By synthesizing concepts from service operations, marketing, strategy, organizational behavior, and information systems literature, we conceptualize an integrated framework of new service development for retail services, with key elements as depicted in Figure 1. We show how the concept of "sticky information" (von Hippel, 1984) is useful in understanding the economics and diffusion of service innovations transfer across retail chains[2]. Service operations management literature, for example, has explored how service firms might organize themselves for accelerating new service development and innovation (Johne and Storey, 1998; Johnson et al., 1999; Menor and Roth, 2007, 2008 provide comprehensive reviews of this literature). Knowledge management literature (e.g., Szulanski, 2000), on the other hand, has discussed transfers of "sticky" global information about new policies and procedures to local service establishments (chain outlets), where stickiness is "the incremental expenditure … required to transfer a unit of information to a specified locus in a form useable by the information seeker" (von Hippel, 1998, p. 629).

Researchers acknowledge that sticky information (or know-how) is more costly and difficult to transfer than is non-sticky (or more routine) information. Because of the inherent complexities of "what is being transferred," namely, both new service/product bundles and supporting delivery systems, a central notion of new service innovation research is this: new service offerings and concepts will often require sticky information transfers of new knowledge gained from customers, competitors, etc. As depicted in Figure 2, a service offering is defined by all the elements that customers may purchase. This "bundle" is particularly complex because it includes multiple tangible and intangible elements that are intricately linked together: (1) explicit services, (2) facilitating goods,

2 The transfer of information in a retail chain service, where the service bundle is more complex, is posited to be somewhat "more sticky" than transfer of transaction-based information innovations. (See Roth and Menor 2003 for elements of the service bundle.) Take for example Best Buy's introduction of electric-powered bikes (see section 3.1 below). We note the "physical" part of a more complex service innovation package that required "experts" (e.g., Geek Squad) for sales and maintenance.

(3) supporting facilities, (4) facilitating information content, (5) implicit benefits, (6) sensations, and (7) peripheral services (Sasser et al., 1978; Menor and Roth, 2003; Fitzsimmons and Fitzsimmons, 2008). All of these elements must be aligned for the customer experience; and therefore, each must be conveyed simultaneously in a new service concept transfer across the chain. Thus, the importance of managing the bundle "holistically" across a geographically dispersed chain is one major reason for information/know-how stickiness.

• **Explicit services** (core transaction)	Satisfy hunger, transportation, surgery, ATM banking transaction, entertainment
• **Facilitating goods** (physical items and amenities used)	Food, ATM/debit cards, forms, receipts, checks, internet connection devices, packaging golf clubs
• **Supporting facilities** (brick and mortar)	Servicescape, store décor, store technology and equipment, store or branch network, kiosks
• **Facilitating information content**	Directions, schedules, fee structures, data, medical records, web page design, diagnostics
• **Implicit benefits** (psychological benefit)	Comfort, status, convenience, feelings of well-being, relief, safety
• **Sensations**	Taste, novelty, imagination, "eye candy," fun, delight, WOW! factor
• **Peripheral services**	Services/Facilities that supplement or "surround" the core service (e.g., valet parking for hospitals, shopping at airports)

Figure 2 New Service Customer Experience Concept
(A "Complex Bundle" of What Customers Buy, adapted from Sasser et al., 1978; Roth and Menor, 2003)

A second major reason for such stickiness has to do with the service delivery process itself. Namely, services involve the customer in the production process. As a result, service organizations have four generic attributes that separate them from goods producing companies (i.e., simultaneous production and consumption; time perishable capacity; intangibility of ideas, concepts, and solutions; and heterogeneity [variation] of outcomes from customer to customer) (Fitzsimmons and Fitzsimmons, 2008). We posit that collectively these generic attributes of services contribute to the information stickiness of a new service concept. Accordingly, transferring new service innovations across a retail chain will be more intricate and costly than conventional wisdom may dictate.

New service offerings or ideas can also be likened to a firm's best practices (Szulanski, 2000) that require transfer and execution by remote retail chain outlets. However, understanding the difficulty and cost of these service innovation transfers is critical. As a result, the following two questions should be explicitly considered when RCS strategically evaluate their decision to diffuse the innovation organization-wide: (1) What internal and external factors influence the development of new service concepts or offerings? (2) How will the operational know-how related to the new service offering be best transferred throughout the retail system? Importantly, transferring service innovations across the retail chain system will "involve a unique combination of human and information systems…Ironically, to leverage knowledge … [the firm] will need to focus on the community that owns it and the people who use it, not the knowledge itself" (McDermott, 2000, pp. 23, 28). In this sense, we view the "community" as the totality of the RCS organization, and it is the subject matter of our discussion.

In practice, organizational routines and habits can become embedded throughout the community of RCS outlets, which creates a "groupthink" dilemma for common owner (replicator) managers. Groupthink occurs when organizations share common experiences or ideologies which may indirectly influence psychological consensus (Janis, 1982). On the one hand, groupthink is beneficial to chain operations, as it may help to achieve operational consistency among RCS outlets. On the other hand, groupthink can be a barrier to successful sticky new information transfer, as it may inhibit the growth of new ideas and the diffusion of new product or service innovations. Moreover, new service concepts need experimental testing in actual service environments to evaluate their benefits. While new service offerings are relatively easy to manage in a small number of retail locations, often they are not easily replicated over a wider chain network encompassing hundreds or perhaps thousands of similar domestic and international retail outlets.

In summary, by considering new service concept development, technology use, and delivery system strategy (Roth and Menor, 2003) within the context of "new" information transfers to chain outlets, service scientists might better understand why some new services successfully replicate and others do not. In addition, there is little research to guide practitioners on how to design organizational systems to spread new service concept ideas (Kaplan and Norton, 2008). The area of innovation transfer in globalization retail services is even less understood by service providers (Roth et al., 1997). This is particularly problematic in RCS, where there is both cultural and geographic distance between the information source and the information seeker, and when the new service operating knowledge may be difficult to transfer with any precision (Xue and Field, 2008). Moreover, Weng et al. (2009) have found that commonly held beliefs of service recovery on outcomes differ significantly between U.S. and Taiwanese customers. Collectively,

these studies and cases of service management suggest that not only will domestic service innovation transfers be difficult but also that international transfers may be even more so, since Western models are not a 'one-size-fits-all' for globally dispersed customers. Next we discuss our organizing framework, which serves as the basis of a research agenda.

2. Conceptual framework development

In this section, we present the theoretical basis of our framework and propositions. The Figure 1 framework provides guidance on how information and communication technology (ICT) might be used to aid in transferring the stickiest of information throughout a chain organizational system. At the center of our internal integration model is organizational dialogue, which we argue is a key theoretical indicator of consensus among the network of RCS outlets and common owner. Supply chain research has argued that the level of consensus in groups is driven by the ability of teams to pool and share information (cooperation); the volume and type of information that is shared between group members (measurement); and the status, backgrounds, and locations (proximity) of group members. Since RCS members are often challenged by a lack of proximity among departments and to the common owner, it becomes increasingly difficult for a centralized R&D group to pool and transfer new service information and know-how to all outlet locations. Therefore, it is important that integrative design practices are in place first to foster a common vision and understanding of the new service concept in its development stage, which will enable deliberate regional modifications to the concept as required and will mitigate unplanned deviations. Second, the appropriate organizational structures and measurement systems must reinforce the concepts and their internal transfer.

Because internal integration is the last stage of sticky information transfers (Szulanski, 2000), and because RCS suffer from many of the natural impediments (Szulanski, 1996) to such transfers (e.g., distance from the locus, cultural differences, causal ambiguity of new service offerings, and lack of absorptive capacity at the receiving chain outlet), achieving "robust" organizational internal integration platforms is particularly important for chains to avoid costly disruptions from new service or product offering implementations (Kaplan and Norton, 2006). Internal integration practices using ICT support the strategic alignment necessary within an organization to achieve higher levels of innovation performance and to overcome information barriers to operations (Pagell, 2004). As such, the current research on internal integration leaves many opportunities to focus new research efforts in RCS contexts for the study of new concept development and diffusion. This point is important because achieving a degree of internal organization is a prerequisite to external integration in any operational system (Hillebrand and Biemans, 2003, 2004).

Organizational internal integration research has examined dyads between internal production functions like marketing and operations (Verma et al., 2001; Hausman, Montgomery, and Roth, 2002) and marketing and logistics (Ellinger, Daugherty, and Keller, 2000); and production triads like marketing, R&D, and manufacturing departments (Kahn and McDonough, 1997). Much of the prior related organizational research focuses on only one technology or element in an integration system, such as the use of electronic commerce technologies (Subramaniam and Shaw, 2002), information technology (Narasimhan and Kim, 2001), or specific purchasing practices (Min and Galle, 1999). Few studies examine integration in organizations from more of a holistic (unified) perspective (Froehle et al., 2000; Pagell, 2004; Kaplan and Norton, 2006), or from the perspective of deploying a new service concept idea throughout an organizational system with many remote outlets. Regarding the latter, the academic literature on franchises is perhaps the closest to meeting this goal (Fitzsimmons and Fitzsimmons, 2008). Specifically, we discuss how each of the integration practices argued for in the model might benefit RCS organizations.

2.1 Organizational dialogue

Organizational dialogue is at the center of our information and knowledge transfer framework. Organizational dialogue has been found to be linked with organizational learning and knowledge transfer processes within firms (Roth et al., 1994; McDermott, 2008). In this research, organizational dialogue is operationally defined by an iterative cycle of communication and consensus building within the RCS organizational community. Organizational dialogue facilitates the sharing of understanding, information, and know-how among entities in RCS communities, and it is a key enabler of internal integration. Moreover, dialogue is required even if the new innovation comes from an external source (e.g., from a customer or competitor), as it enables the organization to assimilate diverse ideas and concepts more efficiently (Zahra and Nielson, 2002). In this sense, organizational dialogue is a prerequisite for the firm to begin achieving the benefits of external integration and external knowledge (Froehle et al., 2000), by providing the intermediate mechanism needed to digest and internally process newly acquired knowledge.

Arguably, the quality of the organizational dialogue is first associated with internal integration, and in turn, the relative efficiency and effectiveness of new service concept development and deployment. Theoretically, internal integration is the process of interaction by which departments within the same organization work together in a cooperative manner to arrive at mutually acceptable outcomes (Kahn and Mentzer, 1998; O'Leary-Kelly and Flores, 2002; Pagell, 2004). Hildebrand and Biemans (2003) suggest that internal cooperation and collaboration are, in fact, conceptually the same, and the internal dialogue they create contributes to the establishment of a continuous

learning cycle within a firm. Therefore, interaction mechanisms, including ICT, that link communication and consensus-building functions are necessary for attaining the requisite level of organizational dialogue.

Unfortunately, the extant integration studies focus mostly on the presence of ICT, not the organizational functions of ICT to transfer new information and build consensus (Pagell, 2004). McDermott (2008) argues that information technology can inspire knowledge, per se, but is limited without the requisite community building activities -- technical, social, managerial, and personal -- that connect "people so they can think together" (p. 22). Pagell's (2004) case studies in supply chain management suggest that the mere presence of integrative ICT is not what actually drives internal integration. Instead, its ability to stimulate both formal and informal communication to build consensus among people in the organizational community and to work towards implementation of a goal are the keys. Integrative ICT's value is in that it fosters internal cooperation and measurement (Vickery et al., 2003), which both positively influence the level of organizational dialogue that is present. Taken together, the above research suggests the following propositions:

P1a: ICT that enables communication and consensus building between the common owner and RCS outlets has a direct and positive influence on internal integration.

P1b: RCS internal integration has a positive influence on the RCS ability to achieve external integration.

P1c: RCS internal integration mediates the relationship between ICT and organizational dialogue.

P1d: Combinative RCS internal and external integration (versus internal integration alone) mediate and enhance the relationship between ICT and organizational dialogue.

2.2 New service concept development

New service concept development refers to the processes whereby the organization comes to know (1) its target market(s) and its customer needs or desires, and (2) how its innovation processes are linked to its competitive intentions and service strategy (Edvardson and Olson, 1996; Menor and Roth, 2008). Accordingly, market acuity, or the "ability of the service organization to see the market environment clearly" (Menor and Roth, 2007, p. 828), is identified as a main component of developing successful new service concept offerings. Information related to a newly developed service is then successfully processed when organizational mechanisms are properly aligned both internally and with the external market. This alignment is particularly important for

radical innovation transfers to be successful (Johnson et al., 1999). New service concept development is only possible to execute consistently when the service strategy within an organizational system is cohesive (Goldstein et al., 2002, p. 124). Therefore, new service innovations will be more successful when the integrative parts are already in place; they are not built-in after the fact (Johnson et al., 1999). As such, our multidisciplinary model does not focus on the process of new concept development in chain services per se; rather, our focus is on what integrative resources must be in place to make information and knowledge-transfers more efficient in such systems. We propose that the organizational dialogue and cohesion that is created by building internal organizational integration practices is the essential driver of an effective new concept development process in a widely distributed chain network, particularly when information is more difficult and costly to transfer (sticky).

In summary, prior related work suggests that communication and consensus building are key indicators of the internal integration that influences new service development processes (Froehle et al., 2000). For RCS, this organizational dialogue--stemming from the internal communication and consensus building cycle--is an important indicator of the firm's innovation capabilities because it helps span the distant boundaries of the firm to distribute knowledge. This, in turn, enables the successful internal development and transfer of a new service concept. Therefore:

P2a: Organizational dialogue positively and directly influences the efficiency of new service concept development intra-firm transfer between the common owner and RCS outlets.

P2b: Organizational dialogue that is associated with combinative internal and external integration positively influences the marketplace effectiveness of intra-firm new service concept development processes.

P2c: Organizational dialogue in RCS has a greater influence on new concept development processes when new service information and know-how transfers are "sticky," versus when new service transfers are more easily codified.

2.3 Structural cooperation

Structural cooperation is characterized by the firm's embedded attributes--leadership, policies, culture, and incentives -- that set the overall service climate for change (Roth et al., 1997). Structural cooperation facilitates combinative internal and external integration, and importantly, the opportunity for such integration to be exploited by RCS stakeholders. The new service development literature argues that overarching organizational structure plays a critical role in facilitating the usefulness of internal integration practices to drive shared organizational dialogue (Froehle et al., 2000). ICT has the potential to decrease

coordination costs and transaction risks in interdepartmental collaboration because it creates a communicative structure to share sticky information; however, in emerging research Oliveira and Roth (2009) suggest that service climate factors are important antecedents of a firm's ability to benefit from ICT deployments. It is only by using the communication functions of ICT effectively that remote actors are able to take constructive actions to mutually solve fuzzy problems.

Structural cooperation among organizational stakeholders will help (or hinder) in executing a new service concept idea, because it leverages organizational and market knowledge for some greater purpose. For example, the Starbucks coffee chain's early recognition that its Italian espresso-bar design was not a critical component of its business template (or a best practice) was an important step in recognizing which operating parts of its business needed to be replicated exactly by the chain outlets globally (Schultz and Yang, 1997; Winter and Szulanski, 2001). Moreover, the incentives for information exchange must be "non-rivalrous" in use with respect to how to reproduce and operate a successful business best practice (Winter and Szulanski, 2001, p. 733). In examining the home electronics chain Tweeter, DeHoratius and Raman (2007) found that the organization's incentive program had a strong positive effect on chain store manager behavior, with respect to implementing new retail strategies and priorities. Therefore, for new service strategy implementations to be successful, a necessary condition is the structural cooperation of stakeholders. We posit that in successful service innovation environments, the appropriate leadership and incentives will be in place to foster shared communication about best practice templates and their relative performance versus expectations.

The organization's structural cooperation will determine the level of communication -- defined as the amount of verbal and non-verbal interaction, both formal and informal, that can take place between the outlet operators and the central owner. Several research models demonstrate that location and proximity are key antecedents to internal integration, primarily because of the fact that location proximity tends to stimulate more communication (Pinto, Pinto, and Prescott, 1993; Pagell and Lepine, 2002; Pagell, 2004). However, the physical separation of corporate headquarters (e.g., service support center) and the local service establishments (e.g., outlets) provides challenges to internal integration in RCS. Remote RCS outlets may, therefore, not achieve high levels of internal integration without the aid of strong leadership, culture, policies, and incentives, which act together to make the communication between parties more valuable in achieving consensus (Roth et al., 1994). OM research further suggests that well-designed measures and performance systems are important levers for creating integration and consensus only when the surrounding corporate environment is supportive of these systems (Froehle et al., 2000; Pagell, 2004).

In RCS environments, strategic plans, policies, and new initiatives often originate in the corporate headquarters and then are communicated to the retail outlets (Lal, Knoop, and Tarsis, 2007). Location managers are often left to interpret and execute these policies without any sort of additional support or opportunity for input. For RCS organizations, new corporate policies and initiatives can be communicated formally through a variety of methods, including formal memos, service intranet systems, or mandatory manager meetings. Policies and initiatives may also be communicated informally through phone calls and emails from divisional managers, or in regional meetings of service management teams. While the frequency and use of both formal and informal communication are operationally important, the informal communication often occurs much closer to the actual problem-solving event; and this frequency increases the likelihood that all managers impacted by a new service or product issue will actually talk about it (Pagell, 2004). As the level of communication among the RCS community increases, a higher level of organizational dialogue is enabled to mutually solve problems.

RCS can learn from each other by increasing structural cooperation. When the causal ambiguity surrounding a new service offering is present, research suggests that structural cooperation will help transfer the stickiest of the new information and know-how (Szulanski et al., 2004). Darr, Argote, and Epple (1995), for example, found that pizza franchises experience operational learning in the same way as manufacturing environments, such that locations under the same ownership structure learn best practices from the experience of other locations at a much faster rate than those locations with multiple owners. Services that are part of the same ownership or authority network also tend to transfer new product or service information through informal phone calls and personal meetings about best practices more frequently. It appears that when more locations communicate together about a new innovation element they learn to improve the process and better their collective performance (Darr et al., 1995; Pagell, 2004).

These lines of reasoning lead us to make the following propositions:

P3a: Structural cooperation positively and directly influences combinative internal and external integration among the RCS community.

P3b: Structural cooperation influences the relative effectiveness of ICT's mediation role in increasing RCS organizational dialogue.

P3c: Structural cooperation has a greater influence on organizational dialogue in RCS when new service information and know-how transfers are sticky, versus when new service transfers are more easily codified.

2.4 Measurement competence -- the 3S's

This study operationalizes the term "measurement competence" to describe the degree to which internal organizational metrics systems "help quantify the efficiency or effectiveness of action" of remote organization activities (internal quote from Neely, Gregory, and Platts, 2005). ICT serves an important role in building robust measurement systems. Success at achieving internal integration is contingent on effective change management through measurement (Shapiro, 2002; Pagell, 2004). Literature has defined performance measurement as a system of metrics used to broadly quantify the efficiency or effectiveness of an action (Neely et al., 2005). Take for example balanced scorecard decision support systems that have the goal of establishing dashboards to incorporate numerical expressions of firm strategic, operational, and tactical policies (Eckerson, 2006). These systems should embody data warehousing capabilities that integrate service input with output measures designed to optimize performance. Performance measurement systems help facilitate the consistency of an action or decision (Mintzberg, 1978; Roth et al., 1997). At the same time, they stimulate action by internal stakeholders (Neely et al., 2005). Therefore, as in supply chain management (Pagell, 2004), ICT can influence performance management in RCS when it supports the other organizational factors that lead to internal integration and consensus.

We characterize organizational measurement competence by the 3S's: (1) service standards; (2) systems that have adequate informational richness and internal reach; and (3) sensing mechanisms (technology) that help detect and monitor the effectiveness of new corporate strategic actions in the internal or external environment.

2.4.1 Standards

Standardized performance measurement has been shown empirically to be a best practice among service exemplars (Roth et al., 1997). Such systems create a common language within the organization (Winter and Szulanski, 2001). Likewise, goal theory states that when goals are explicitly specified, monitored, and tracked, they will produce higher levels of performance than will vague, non-quantitative goals (Linderman et al., 2003). The performance measurement research also suggests that the design of a performance measurement system should not be in conflict with other measures at different levels within the organization (Fry and Cox, 1989). Furthermore, the overall measurement system has to be consistent with firm strategy in order to achieve high levels of coordination (Lorange, 1982; Hrebiniak and Joyce, 1984). Standardization and specification of work measures immediately enhances the problem-solving abilities of employees in more complex and dynamic service environments by immediately revealing problems (Spear, 2005).

2.4.2 Systems

Research suggests that problem-solving processes benefit from both information richness and reach in a technology or measurement system. Information richness in this context is the degree to which the measurement system provides "information to change understanding within a time interval" (Daft and Lengel, 1986; 1990). Rich measurement systems help resolve ambiguity in an organizational system quickly, without unnecessary effort or time, to convey understanding of a specific situation. Oliveira and Roth (2009), Rosenzweig and Roth (2007), and Hales (2005) empirically demonstrate that information richness is a critical element in B2B ICT effectiveness because it makes communication systems more useful in solving difficult problems. In service operations theory, information richness is a significant determinant of how much human contact is needed to deliver a service effectively (Kellogg and Chase, 1995). Additionally, there is evidence that data dashboard systems in highly integrated firms need to provide enough detail to examine the root causes of problems (Vickery et al., 2004). Advocates of balanced scorecard techniques suggest that when business units are held accountable for certain measures, they must also understand and be in control of the determinants of the measures to improve their performance (Kaplan and Norton, 1992), as well as be able to monitor their performance by analyzing the measures.

The degree to which a wide distribution of information through a technology is supported throughout the organization can be called the "internal reach" of the measurement system (Hales, 2005). The use of ICT infrastructure to communicate across business units is critically important to leverage internal integration capabilities (Subramaniam and Shaw, 2003). Research on electronic data interchange (EDI) and B2B e-commerce applications shows that the benefits of technology are achieved when the information it produces is broadly accessible (Subramaniam and Shaw, 2003; Hales, 2005). Therefore, broadly pooling information across diverse parties will lead to improved group performance (Mohammed and Dumville, 2001).

2.4.3 Sensing

Sensing technology that gathers performance feedback on a new service innovation has been widely discussed as a means to monitor the effectiveness of any action or behavior. See for example Pampino et al. (2003) and Nolan et al. (1999), who provide comprehensive reviews of the organizational behavior literature in this area. Whether or not feedback systems need to provide immediate information or delayed feedback on processes or new product introductions is subject to debate, but it is clear that feedback systems are important in services (Voss et al., 2004). Sensing technology will work best in chain service environments when it is used along with other supporting behavioral control procedures (Pampino et al., 2003, p. 35). Moreover, lead users of new technologies or

services are much more likely to provide feedback on their effectiveness than are users in less sticky information transfer environments (Magnusson et al., 2003). For example, firms can use CRM technologies to effectively identify opportunities to improve new service concepts or offerings in much the same way that independent software developers participate in open-source communities to gather information and customize new product/service offerings (Magnusson et al., 2003; Jeppesen and Frederiksen, 2006).

Because measurement plays a critical role in aligning networked organizations, the degree of measurement competence in the 3S's performance measurement system is posited to improve internal dialogue and consensus in chain service organizations. If all three important measurement capabilities are in place, then RCS will have a high level of measurement competence and be able to discuss sticky new service problems in a meaningful way. Therefore:

P4a: Measurement competence positively and directly influences combinative internal and external integration among the RCS community.

P4b: Measurement competence influences the relative effectiveness of ICT's mediating role in increasing RCS organizational dialogue.

P4c: Measurement competence has a greater influence on organizational dialogue in RCS when new service information and know-how transfers are sticky, versus when new service transfers are more easily codified.

2.5 External stimuli

New service concept development is a dynamic and fluid process in RCS that requires information transfers from both within and outside of organizational boundaries. In particular, important sources of new information that can be used in developing a new service concept can and should come from external sources. We define these external sources as two general types: customer stimuli and environmental stimuli. Customer stimuli are those elements of the target market that permit new service innovations to be offered to them. Roth and Menor (2003) argue that understanding the specific nature of the target market is critical for any effective new service strategy. McDonald's, like many retail chain stores, tailors both its overseas menus and operations to fit in with foreign target market tastes and customs.[3] Similarly, environmental stimuli determine the degree to which technological progress or social dynamics influence the target market for a new product or service. Environmental stimuli play into the new service development process by adapting to the target market's needs over time and by identifying new opportunities to serve the target market.

3 McDonald's has run a varied menu in its 1996 overseas stores since the early 1990s. *See* Friedman, M.L., "Foreign Affairs Big Mac 1," *The New York Times*, Dec. 8, 1996.

We posit that the ability of the organization to digest customer and environmental stimuli from external environments toward some meaningful purpose (e.g., to transfer sticky information or to get feedback from customers back through the system) is affected by the degree of structural cooperation, measurement competence, and new concept development processes. Without building the corresponding integrative capabilities and organizational dialogue, however, the key stakeholders may not view these external stimuli as opportunities but rather as "primordial soup" that has no relevance to the target market. In a similar vein, Johnson et al. (1999) note that "innovative firms having a higher level of absorptive capacity are by definition able to identify, extract, and exploit information to facilitate ongoing development efforts quickly and effectively and are in a more advantageous position to make the most of future development opportunities" (p. 19). Therefore, the integrative capabilities developed within a distributed innovation system are most important in the early opportunity development and product/service creation cycles, when information transfers are likely to be the stickiest (Noori et al., 1997).

3. Discussion

In discussing the model factors and their implications, we give an illustrative example. We then discuss how ICT, integration, and information stickiness play several important functions in a retail chain's organizational success and sustainable competitive advantage.

3.1 Example of the integration model elements -- Best Buy customer-centricity stores

Effective new service offering transfer is seen in the U.S. chain retail landscape with what Best Buy calls its "customer-centricity" stores. For Best Buy, customer centricity is a mechanism that is used to enter into new product and service ventures. By 2009, the organization-wide customer-centricity approach had given Best Buy an integrative new concept development system and the opportunity to begin selling "green vehicles" in 19 of its U.S. retail store outlets (Bustillo and Wingfield, 2009). These "green vehicles" include futuristic electric-powered scooters, bicycles, and Segways, that are new products to the market, geared toward lead users of technology, and are highly information intensive with a price point of about $11,000 per bike. The new product offering initiative is, in part, a response to an emerging customer interest in environmental sustainability, technological progress, and a dynamic retail market that has developed outside of the firm's boundaries but is still within Best Buy's core target demographic. First, environmental stimuli from outside the organization are affecting Best Buy's new product and service offering choices, as it attempts to capitalize on a sustainability and environmental movement with its new e-bike offering. In addition, the new product offering endeavor is taking place

in customer-centricity stores specifically tuned to pre-defined target markets (customer stimuli) where stores tend to be located in younger, more urban, and more highly educated communities. Potential e-bike customers may therefore already be coming into these Best Buy stores for their information-intensive consumer electronics services and products (Lal et al., 2006; Shockley, Roth, and Fredendall, 2009).

The introduction of the electronically-powered bikes and complementary supporting store services is a new service innovation "bundle" that requires internal integration and a sticky knowledge-transfer of know-how to sell the new "green vehicle" concept across the greater Best Buy store network. The customer-centricity approach gives specific Best Buy store managers the ability to focus on the active selling of lifestyle solutions (e.g., bundling of different products and services) tailored to individual pre-defined customer segments (target markets), versus a less targeted "one-size-fits-all" self-selection/ superstore model of chain store retailing which may not be suitable for every target market environment.

In creating the customer-centricity store concept in 2002, Best Buy management recognized that it had to provide a more value-added service offering to compete effectively versus Wal-Mart and other U.S. low-cost segment competitors (Boyle, 2006). Since then, customer centricity has become the strategic mechanism Best Buy uses to periodically retune its store designs, merchandising, and store selling-system strategies for new concepts and service offerings (Bustillo and Wingfield, 2009). Customer-centricity stores incorporate system-wide adjustments to compensation strategies, communication procedures, and performance measurement systems that then may be integrated throughout the wider chain store network (Lal et al., 2006). While the retailer's transition to more high-contact store services (e.g., leveraging its "Geek Squad" technical services and other high-contact store resources in a cost-sensitive selling environment) has met with struggles from time to time, many of the new service and product offerings initially targeted in these experimental stores have ultimately increased sales and profits once deployed across the wider chain store network, and it has been beneficial as lead users of new product offerings were replaced by more functional users in the general population over time (Lal et al., 2006).

New service concept development at Best Buy may at first appear to have a top-down implementation strategy common in many U.S. chain store service systems. However, new retail ideas and strategies are actually crafted from within pre-established chain service communities, and ideas are shared through both formal and informal communication practices. Internal performance measurement systems are then tailored to create organizational dialogue about a new service concept in a particular market setting. This know-how can then be recycled back through other stores, buyers, and suppliers to communicate and build internal consensus and improve the new service strategy

(Froehle et al., 2000). New service concepts or product bundle offerings, like Best Buy's offering of "green vehicles," are often defined by how the service intends to serve customers (Goldstein et al., 2002; Roth and Menor, 2003). Yet, at Best Buy, new service concepts get incorporated into the organizational design architecture through the informed strategic choices that key organizational stakeholders make about structure (e.g., service layout and physical facility), infrastructure (e.g., human resource policies/ job designs), and the coordination of internal and external resources that create differentiated service experiences and enhance customer-perceived value (Roth and Jackson, 1995; Voss et al., 2008). Of these three architectural components that make up service strategy, Best Buy leverages its coordinative capabilities from the customer-centricity program to support both a cooperative structure and robust measurement capability that allows it to optimize the new product offering for its intended target segment. For e-bikes, an information-intensive and potentially highly-sticky new product offering, this shared know-how gives it some competitive advantage with its target market. Best Buy's competitors, which may have neither the same knowledge-creation network nor the same relationship with the target market, may not be able to bring such a new offering to economic scale as effectively.

3.2 ICT, integration, and information stickiness

Critical to understanding new concept development processes, as depicted in Figure 1 and the Best Buy example, are the internal and external integration practices that are enabled by the structural cooperation and measurement functions of ICT. Yet, relative to research in manufacturing environments such as computer- aided design and manufacturing, ERP, and MRP systems, the use of ICT in service systems is only recently gaining more research attention (Roth and Menor, 2003; IFN and IBM, 2007). Service science oriented literature suggests that computing plays a critical role in the ability to bring to immediate scale the communication, storage, and internal processing of new service concept information (Rust and Miu, 2006). Our post-industrial society is information-based, with internal and external service systems connected by people and technology, and with the service value proposition often based on shared information among corporate stakeholders (Spohrer et al., 2007, p. 73). Once codified, new knowledge can and should be used to analyze and suggest solutions to customer problems when customer co-production roles fall outside the routine (Hefley and Murphy, 2008), as may frequently happen when sticky new service concepts come to market.

As such, ICT is a critical element in bringing new service offerings to economic scale and in overcoming the impediments to information transfer (Froehle et al., 2000). Stickier information transfers may also need to involve more complex combinations of tacit and codified knowledge to be useful in a chain network. Zysman (2006) suggests that the digital or algorithmic transformation of service ideas occurs only when service

tasks (or information/knowledge) can be easily converted into "formalizable, codifiable, and computable processes with clearly defined rules for their (scaled) execution" (p. 48). While more formal sharing of information within chain service organizations occurs through established reports or performance measurement systems, ICT also enables the more informal (more communicative) sharing of tacit knowledge, which is critical to success if new concept information transfers are sticky (von Hippel, 1998).

Research suggests that to reduce information stickiness from a new service (or product) offering introduction, chain service organizations must: (1) determine the best way to provide early opportunities to transfer the stickiest of the new information, and (2) proactively reduce the factors that impede its transfer (Szulanski, 2000). Prior work examining information stickiness has looked at its sources in addition to the facilitators of, and the barriers to, knowledge transfer of best practices across projects and organizations (Szulanski, 1996; Szulanski and Capetta, 2003; Szulanski et al., 2004; Haas and Hanson, 2005). The three major barriers to sticky information transfers can be: (1) the information recipient's lack of absorptive capacity (Cohen and Leventhal, 1990); (2) the failure to understand the causal relationships of the information being transferred, and (3) the relative distance between the source of the transfer and the recipient (Szulanski, 1996; Xue and Field, 2008). These environmental conditions are also typically seen in RCS organizations that periodically must make new service or product offerings to remain competitive across different service environments -- like McDonald's, Starbucks, Best Buy, etc. Szulanski (2000) contends that internal integration is at the last stage of the successful information-transfer cycle; while in the earlier stages of transfer, organizational system design strategies should focus on providing a wide range of new information-sharing opportunities to exchange the more tacit elements of the new innovation.

One of the characteristics that makes service production systems unique is that co-production occurs between customers and servers (Xue and Field, 2008). Co-production is the simultaneous production of the service tasks that takes place in service encounters between the customer and the server, which may be an employee or technology system-server (e.g., ATM, Website, etc.) (Xue and Field, 2008, p. 359). For example, effective deployment of a new server technology may involve several co-production roles, such as providing information-handling processes that are more dependent on the transfer of either tacit knowledge (e.g., through the knowledge-base of a service employee) or explicit knowledge, relying on supporting routines and analytical technology systems to aid in the information transfer (Huete and Roth, 1988; Froehle et al., 2000). In the case of lead users of new services -- those individuals who are more likely to need the human server to transfer the stickiest of information -- the value of the new service offering is often in its ability to effectively problem-solve using more tacit information transfers from other lead users (Oliveira and von Hippel, 2009). Once designed, new service offerings requiring

sticky information transfers are often executed and implemented very poorly because chain outlet service managers fail to understand the role of the new offering within the existing operating system strategy (Darr et al., 1995).

3.3 Sustainable competitive advantage

Sustainable competitive advantage will be achieved when the integrative elements of the conceptual framework (Figure 1) are in alignment, and the functions of ICT help facilitate organizational dialogue among key stakeholders. Internal integration is both a key determinant of organizational performance and of long-term competitiveness. Hayes and Wheelwright (1984) state that, at the strategic level of analysis, organizational internal integration is linked with a firm's long-term competitive advantage. Parasuraman, Zeithaml, and Berry (1985) suggest that a service's perceived "quality" is the service system's capability of delivering a favorable "comparison between (customer) expectations and performance," and improved understanding and execution may lead to competitive advantage in the marketplace.

New service concept success is also critical for retail chains to stay relevant to their target markets by exceeding those expectations. Therefore, the principal outcome of better integration practices is organizational dialogue that accelerates the innovation/introduction cycle and simultaneously improves its performance: execution, efficiency, flexibility, and -- importantly -- new service innovation transfers in chain service systems. Taken together, structural cooperation and measurement competence are posited to deliver highly integrated RCS organizations, with rich organizational dialogue that makes new concept development more effective. Taking a multidisciplinary view of new service concept information and know-how transfers helps explain how retail chains can and do achieve competitive advantage in these areas.

4. A way forward: A research agenda for retail chain services

We have argued that RCS might achieve and manage new concept information transfers more effectively by designing their organizational systems to support key integrative practices. Specifically we posit that both structural cooperation and measurement competence foster internal integration most effectively by using information and communication technology (ICT) to enhance organizational dialogue. This organizational dialogue then influences new concept development process effectiveness by stimulating the communication and consensus building activities that integrate knowledge back through the new concept development process. In addition to examining the propositions related to our framework (Figure 1), we develop several researchable questions from a review of information stickiness, knowledge management, and internal

integration literatures, as well as examine the role that ICT plays in building internal integration practices in RCS. New research examining the integration practices that help facilitate these transfers is also warranted. Next, we discuss how answering each of these questions provides an agenda for future service science research to better understand how new service concept development occurs in distributed learning environments (e.g., retail service chains).

Stickiness concerns the cost of new information/know-how transfers related to new services concept development. Roth and Menor (2003) have argued that service strategy and new concept development practices should vary based on whether or not the new service offered is a core service or a peripheral service (Figure 2). However, a new service concept, like Best Buy's "green bikes" product offering, may not be a core service at all but rather a "facilitating good." Yet, its introduction still involves a sticky information transfer because it is part of a "complex product bundle" offered to a specific target market. Szulanski (1996) argues that absorptive capacity of a knowledge-transfer recipient can either aid or hinder the speed of the innovation cycle for a firm in these cases. Research could examine, for example, if there are knowledge-spillover effects from selling and coordinating the sale of big screen TV's and e-bikes in a Best Buy consumer electronics store format.

Question #1: Can service employees really apply prior knowledge and experiences to a completely different product line? How can overall absorptive capacity be evaluated in conjunction with retail information systems in these cases?

In particular, increasing geographic or cultural distance (like a retail chain's expansion into a foreign market) can impede new service concept development if information is sticky to transfer (Jensen and Szulanski, 2004). Yet there is little research that examines how chains overcome cultural distance across or even within geographic areas to deploy service innovations. Both external and internal customers in services have reference points, which they compare against expectations of a service offering (Parasuraman et al., 1985). Many studies using Hofstede's (1980) cultural dimensions framework find that cultures with greater power distance or more individualism will expect a higher level of service. However, there is a great need for studies examining how culture might impact customer expectations of chain services, particularly since these services attempt to cross both cultural and national boundaries. For example, how might sticky information transfers differ across cultural boundaries -- Is a particular sticky transfer for one culture not sticky at all for another? Uncertainty-avoidance differences across cultures may inhibit the knowledge-learning cycle as it involves sticky information transfers. Argote (1991) argues that input uncertainty is a natural impediment to organizational dialogue in

services, and that stakeholders will react to uncertainty in highly variable ways, which is probably not desirable over a chain-wide disintegrated system.

Question #2: What organizational and cultural factors influence the stickiness of new service concepts in retail service chains? What role does absorptive capacity play for RSC communities in "reducing" relative stickiness?

The stickiness of any new service concept knowledge-transfer will influence how ICT will need to be deployed and managed throughout RSC to build organizational dialogue about a new service innovation. ICT's value to new concept innovation, therefore, comes from its ability to overcome distance barriers to build organizational dialogue by either: (1) connecting organizational members in a communicative role, and/or (2) measuring the value-added activities and objectives of the organization. Most literature in operations management concerning the use of ICT to build integrative capabilities indicates a positive relationship to firm performance because of ICT's ability to create systemic knowledge. Specific examples include the use of electronic data interchange (Rassamethes, Kurokawa, and LeBlanc, 2000), computerized production systems (MRP I/II) (Vollman, Berry, and Whybark, 1997), and internet/intranet connectivity in purchasing (Hales, 2005). Vickery et al. (2003) proposes a macro-level construct related to technology called "integrative IT" that includes some combination of MRP, EDI, and "other" integrative systems. Furthermore, studies of B2B integration find that any ICT that spans boundaries both inside and outside of the firm has a positive impact on firm performance (Oliveira and Roth, 2009). While the communicative and measurement roles that ICT plays are often mentioned in these studies, it is rarely empirically examined from more of a functional and mediatory perspective (Froehle and Roth, 2004). More work is needed to understand the impact when different mixes of information in the service concept bundle (Roth and Menor, 2003) are managed simultaneously in retail chain environments.

Question #3: How does the mix of sticky/non-sticky information in the service concept bundle affect information transfer, technology investment, and scaling in RCS? What is the role of technology mediation in scaling?

Despite the fact that most of the literature on internal integration concerns the presence of integrative ICT systems, more work is needed to understand ICT's functional roles in creating organizational dialogue through designing performance measurement architecture, which builds knowledge to aid in the transfer of sticky information throughout the system. Shapiro (2002) suggests that information systems in a supply

chain are based on either transactional ICT or analytical ICT. There is a dire need to construct RCS databases that support decision making (analytical ICT) processes within firms (Shapiro, 2002). Connectivity (transactional ICT) has been oversold in the marketplace because firms have failed to account for the behavioral components of integration practices that require deeper knowledge and understanding (Shapiro, 2002).

Using organizational dialogue as a means to understand internal integration in chains moves research in the area beyond just examining the presence of ICT systems or capabilities (Pagell, 2004), and analyzes what ICT is doing to create knowledge-creation resources and dialogue within the firm. Research is needed to understand how different technology can be used to manage various types of sticky information transfers. For example, do technology systems need to work independently or in conjunction with human-server systems in an analytical or knowledge-creating role? It could also be that some information transfers have certain security or privacy concerns that do not allow them to be transferred readily across a network of providers (Chandra and Calderon, 2005). Our model provides several opportunities and propositions for further empirical examination. One could ask, following Froehle and Roth's (2004) logic, which different attributes of ICT systems may be more or less effective in achieving high levels of internal integration and consensus in more complex service innovation settings -- especially where the majority of new service offerings involve sticky information transfers? It would also be interesting to see if the model we propose is more effective in incremental or radical innovation environments for services, as it has been found to be in logistics innovations (e.g., Germain, 1996). There is further opportunity to understand the role of users in the service concept development (see Oliveira and von Hippel, 2009), and how their involvement may facilitate (or hinder) the sticky transfers. These findings would be useful for organizational consultants, executive officers of service firms, or anyone involved in studying the effectiveness of new service innovation and design programs in these environments.

Question #4: What specific attributes of information and/or external customers and environments facilitate (or hinder) the new service concept information development and transfer process in RCS? Are internal integration practices more important for radical or incremental new service integrations?

Business strategies can be supported by functional strategies that are internally consistent (Pagell, 2004), and internal integration implies that the "heterogeneous departments within the organization are able to act together as a cohesive organization towards mutually acceptable outcomes" (Kahn and McDonough, 1997; Kahn and Mentzer,

1998). In RCS, heterogeneous departments are the service support center (owner) and the local service establishments (outlets). While there is a great deal of literature that examines internal integration relationships across networks, few studies outside of those examining franchises look at new concept development in chains. Because new service development does not happen in a vacuum, research needs to examine how these internal stakeholders communicate and build consensus to effectively deploy new services after they are initially developed.

RCS may face challenges to internal integration because high labor turnover inhibits the knowledge-creation process. Annual turnover rates for employees in service industries in the 1990s, for example, was about 300%, with managerial turnover approaching about 50% (Darr et al., 1995). In addition, many such service providers have only seasonal needs for workers. Therefore, RCS must often manage workers with limited experience and knowledge of business procedures, a fact that may cause confusion regarding job duties and responsibilities (Ramaseshan, 1997; Zeytinoglu et al., 2004). These particular human-resource dynamics suggest that integration, standardization, and rapid learning are critically important in these environments (Darr et al., 1995). However, they also suggest that knowledge must be codified in some way so that it is easily repeatable. An alternative for high-contact environments might be to reward front-line workers directly for the additional knowledge they acquire, or to provide them with empowerment and flexibility to override restrictive policies when they interfere with profit-generating activities (Shockley et al., 2010).

Consensus is an important indicator of internal integration because it assumes that knowledge and agreement already exist within the firm (Pagell, 2004). Higher levels of internal consensus should lead to better performance across a variety of measured outcomes. As we note, Pagell (2004) provides a broad organizational model in which internal integration and consensus are treated as a single dependent construct driven by communication and measurement. Similarly, literature examining group mental models supports the idea that highly diverse group members transfer knowledge more effectively when they collaborate to achieve cognitive consensus (Mohammed and Dumville, 2001). Other research suggests that RCS might actually benefit from becoming more complex, interdependent, and more diverse, as this would help stimulate the knowledge-creation process and help build capabilities to transfer stickier information across functional boundaries (Aiken and Hage, 1968, p. 915).

Question #5: What are the tangible and intangible costs of high turnover in reducing integration and organizational dialogue? How can effective ICT and human resource policies work together to mitigate these costs?

5. Conclusions

Our proposed multidisciplinary framework on new service concept development effectiveness synthesizes multiple disciplines and makes several important contributions to service innovation and service science research. More scholarly research is needed to investigate the relationships at the interfaces of each of these different model elements. Our framework presents a nomological network of related propositions based on existing operations, management/supply chain, service strategy, information systems, strategy, economics, and marketing theories and models; and forms the basis of a *unified theory of integration and distribution of knowledge in retail chain services*. While most studies of integration and new service innovation development examine the supporting structures in manufacturing environments, there is increasing interest in service-integration practices. However, few studies propose internal integration models and organizational design strategies to manage service innovation in RCS systems and organizations. This is ironic given that retail chains suffer from the natural impediments to sticky information transfers, and are increasingly relying on maintaining alignment with specific target markets in more multi-cultural settings.

An important theoretical contribution is made in this paper by examining the role that the information stickiness from a new service offering plays in the transfer of firm best practices in RCS. This framework builds a theoretical platform for future studies of integration in service science because it incorporates insights from diverse ideas about knowledge management, supply chain, and service operations theory. For example, future studies could examine if structural cooperation and measurement competence alone create the basis for effective organizational dialogue to transfer new service concepts; or if something else suggested by the knowledge management and innovation literature, like absorptive capacity at the chain outlet, have to exist to realize that opportunity. Furthermore, do the espoused internal integration practices in the model help service organizations break through the problem of groupthink in service chains, or do they create the ripe conditions for groupthink to be present, and is this always a bad thing? While specific to RCS organizations, this study's stated propositions and proposed research questions offer a number of contexts for research where sticky information transfers are required for new service innovations to be successful, particularly in more distributed or fragmented organizational knowledge systems.

In this paper, we analyze the retail chain service organization because it suffers most acutely from the dilemma of wanting to both standardize formats and innovate, while at the same time it suffers from the natural impediments to new concept transfers. As such, organizational designs in RCS must overcome distance in culture and geography to make these new innovations successful and scalable. We offer insight on the integrative

functions that ICT performs for innovative organizations to be successful, and offer up some important areas for future research. We believe that it is time for research in new services innovation to start examining the transfer of information and know-how in the innovation cycle, to move beyond examining simply the impediments to effective transfer, and start providing the organizational toolkits necessary for firms to master the replication and execution of these new service concepts in applied service environments. It is our hope that this multidisciplinary study of new service offering transfers provides a platform to drive new service science research in innovation in that direction.

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MIS Review Vol. 15, No. 2, March (2010), pp.35-54

Applying a Service Mindset When Thinking and Communicating about Systems and Projects

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ABSTRACT: *Despite the best of intentions, many IT groups have difficulty engaging and communicating with business professionals, managers, and executives they hope to serve. A shift toward applying a deeper service mindset when thinking and communicating about systems and projects might lead to greater success in addressing business issues directly and attaining more effective engagement.*

This paper explains four principles underlying a service mindset for thinking and communicating about systems and projects. These principles lead directly to three frameworks for thinking and communicating about IT-reliant systems. In turn, the frameworks lead to straightforward tools that support business-oriented description and analysis of IT-reliant systems in organizations.

KEYWORDS: *Service Mindset, Work System, Service System, Work System Framework, Service Value Chain Framework, Work System Life Cycle Model.*

1. Introduction

Despite the best of intentions, many IT groups have difficulty engaging and communicating with the business professionals, managers, and executives they hope to serve. At the executive and strategic level, this problem contributes to inadequate business/IT alignment. At the project and operational level, it appears as insufficient user involvement and participation. At either level the impact includes diminished contributions to business success, unnecessarily difficult projects, and frequent disappointments in project results. These problems occur even in IT organizations that have a strong culture of service to the larger organization.

Assume that an IT group's business/IT alignment and user involvement need improvement even though it already has a culture of service. Assume that its staff genuinely wants to provide good service, uses carefully developed processes, has empathy for customers and colleagues, is interested in improving business results, and obtains feedback about service quality using SERVQUAL (Parasuraman et al., 1985) or other tools.

Even with a current culture of service, a shift toward applying a service mindset when thinking and communicating about systems and projects might lead to greater success in addressing business issues directly and attaining more effective engagement.

This paper explains four principles underlying a service mindset for thinking and communicating about systems and projects. Those principles combine ideas from disciplines including information systems, strategy, marketing, and service operations. The main points have been published, presented in conferences, and used by teams of employed MBA and Executive MBA students analyzing systems in their own organizations. Even if your organization already has a strong orientation toward service, you may find value in considering whether its service mindset might be deepened, and how this might be accomplished using these principles or any other set of principles that would be accepted in your organization.

2. Principles underlying a service mindset related to systems and projects

Four principles are the basis of a service mindset related to systems and projects:

1. Interact with business professionals around business topics that they care about.

2. See "the system" as a work system, not an IT system.

3. Assume that value is co-produced with customers.

4. Think of projects as work system projects, not IT projects.

These principles address many of the issues that limit the extent and effectiveness of user participation, which has been discussed many times in the IS literature. The principles suggested here address all three of the common explanations for "how and why participation leads to system success: the creation of psychological buy-in, the improvement of system quality, and the emergence of relationships among developers and users" (Markus and Mao, 2004). These principles support and augment best practices for building and maintaining technical systems through traditional methods or agile methods. They lead to straightforward tools and analysis methods that supplement standard documentation and analysis approaches used in software development. They are most directly relevant to business applications rather than technical infrastructure that is both mysterious and largely invisible to business personnel.

2.1 Principle #1: Interact with business professionals around business topics that they care about.

A service mindset for thinking and communicating about systems requires conversations and analytical tools that truly serve business participants.

IT professionals focusing on the current or future use of hardware and software sometimes find it difficult to interact with business professionals around business topics. Business professionals care most about doing their work, serving their customers, producing business results, and achieving personal goals. They are far more able to interact knowledgably around those topics than around the capabilities and features of software and hardware.

Obviously there is no way to avoid discussing details of software and hardware in many situations. The point of the first principle is that the discussion should be approached within the context of the work setting, business goals, and obstacles to business success. The challenge is to bridge the gap from business concerns to the specifics that IT professionals need to pin down in order to do their own work effectively. Each of the other three principles is the basis of a framework and related tools that can be used to bridge this gap.

2.2 Principle #2: See "the system" as a work system, not an IT system.

Business professionals care most about doing their work, serving their customers, producing business results, and achieving personal goals. All of this happens through work systems that are supported by IT.

2.2.1 Definition of work system

A work system is a system in which human participants and/or machines perform work using information, technology, and other resources to produce products and/or services for internal or external customers (Alter, 2006, 2008). Typical business organizations contain work systems that procure materials from suppliers, produce products, deliver products to customers, find customers, create financial reports, hire employees, coordinate work across departments, and perform many other functions. Almost all significant work systems in business and governmental organizations rely on IT in order to operate efficiently and effectively.

Upon being introduced to work system ideas, experienced MBA and Executive MBA students often see that CRM (customer relationship management) projects in their organizations encountered difficulties because the projects were viewed largely as technology projects concerned mostly with configuring and installing vendor software. In contrast, calling those projects work system improvement projects would have emphasized

improving specific work systems, such as how a firm finds sales prospects, how it enters customer orders, and how it provides customer service. A software configuration and installation project ends when software is installed and used (at least to some extent). A work system improvement project ends when the work system's performance improves. The CRM projects whose difficulties were reported by the MBA and Executive MBA students might have been more successful they had been viewed from a work system perspective.

2.2.2 Definition of service

For our purposes, the ongoing debate in academia about the precise definition of service (e.g., Sampson and Froehle, 2006; Spohrer et al., 2007; IfM and IBM, 2008; Rai and Sambamurthy, 2006) or the precise distinction between products and services (e.g., Leavitt, 1960; Vargo and Lusch, 2004) is not a primary issue. We assume that all purposeful systems produce services, defined simply as acts performed for others, including the provision of resources that others will use. With this definition, every purposeful system in an organization can be viewed as a service because it produces something for someone, regardless of whether it is internally directed (e.g., hiring, accounting, planning) or externally directed (sales, delivery, customer service).

For the purpose of analyzing and designing systems in organizations, the distinction between products and services is useful mainly as a reminder that whatever a work system produces often combines product-like and service-like features. The relevant variables and choices for analyzing and designing product/service offerings are basically about positioning along a series of continuous dimensions such as standard vs. customized, produced for a customer vs. co-produced with the customer, tangible vs. intangible, negotiated in advance vs. improvised, largely back stage production effort vs. highly interactive with the customer, and so on.

2.2.3 Work system framework

The nine elements of the work system framework (Figure 1) are the basis for describing and analyzing an IT-reliant work system in an organization. This framework is designed to emphasize business rather than IT concerns. It covers situations that might or might not have a tightly defined business process and might or might not be IT-intensive. Even a rudimentary understanding of a work system requires awareness of each of the nine elements.

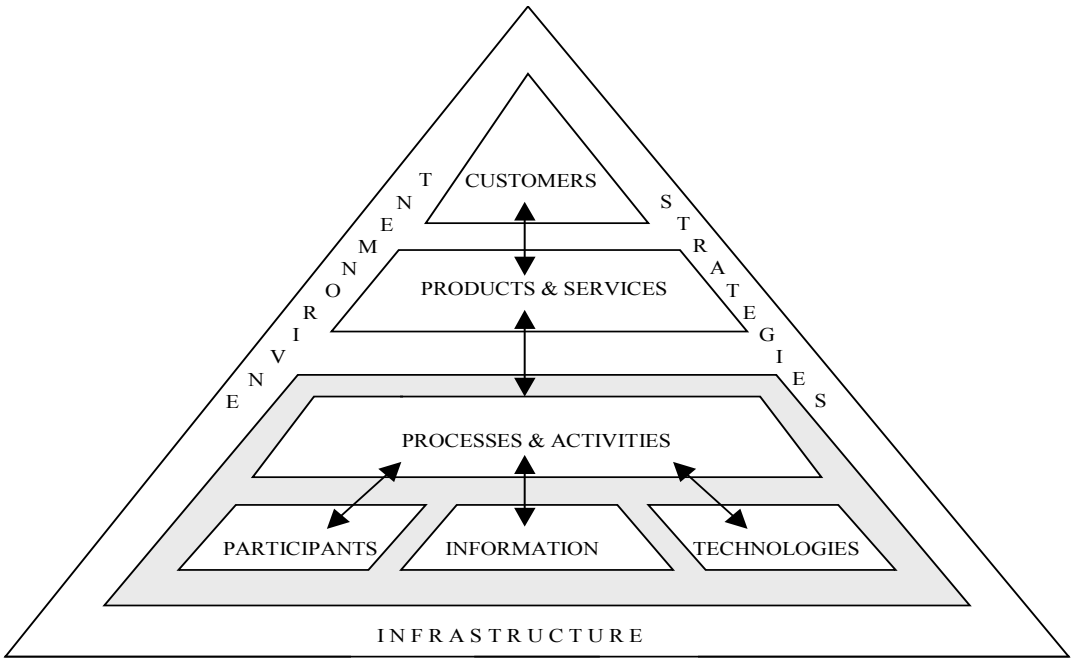

Figure 1 The Work System Framework (Source: Alter [2006])

Placing the customer at the top of the framework is a positive step toward a service mindset for thinking and communicating about systems. Anyone using the work system framework automatically goes through the following thought process:

1. Customers first: The work system exists to produce products and services for customers. Therefore it is insufficient to focus totally on the internal operation of the work system. An understanding or analysis of a work system must include the customer's evaluation of whatever the system produces.

2. Path to customer satisfaction: The arrows in the framework represent the links through which a change in one element might affect another element. Thus, changes in customer needs lead to desired changes in the form, cost, or quality of products and services, which in turn lead to desired changes in the form or performance of processes and activities, and so on. From the other direction, changes in information and technology can always be evaluated based on their impact on both internal efficiency and customer satisfaction.

Placing the work system's customers at the top of the framework and keeping work system customers in view throughout the analysis reflects a deeper service mindset than asking for IT requirements, building IT capabilities that fits those requirements, and assuming that the users of the IT capabilities will be happy. Two years later the IT capabilities may or may not support the work system that would suit customer wants and needs, regardless of whether IT users are happy.

Consistent with its service emphasis, the framework contains slots for customers and participants, but not for users. Customers are the direct beneficiaries of whatever the work system produces. Participants are people who perform the non-automated work in the work system. In many situations, such as self-service work systems that operate through e-commerce web sites, the customer is also a work system participant. The term participants (not users) is included in the work system framework because non-users of IT may play important roles in work systems. The usage of technology may be of secondary importance to key participants in many work systems. Thus, while a typical IT group's focus on users, usage of IT, and user satisfaction is certainly worthwhile, a deeper service mindset would increase the amount of attention focused on all participants and customers.

2.2.4 Work system snapshot

Application of the work system framework to a particular situation can be summarized using a work system snapshot, a one-page summary used to attain agreement about the scope and purpose of the work system that is being analyzed. (See Table 1 for an example.) A work system snapshot uses six central elements of the work system framework to summarize a work system and what it produces. A well-constructed work system snapshot conveys the essence of the work system by identifying the main processes and activities, by being clear about which roles perform each step, by identifying the main informational entities that are used or generated (e.g., orders, invoices, schedules, or bill of materials), and by identifying the main products and services that are produced for customers. Limiting a work system snapshot to a single page avoids excessive detail in the initial stage of the analysis. At this level of summarization, the distinction between technology and technical infrastructure is unimportant.

Work system snapshots are deceptively simple. Many Executive MBA teams have difficulty agreeing on exactly what should and should not be included in a one-page work system snapshot that is produced at the beginning of a work system analysis. If they complain about their difficulty in producing something that seemingly should be easy to produce, it is easy to remind them about the mess that would ensue if they or their organization tried to develop or install software without a negotiated agreement about what work system was to be improved, and what work system improvements were expected. More experienced students often realize quickly that a few hours devoted to attaining agreement about a work system snapshot might have helped their firms avoid significant losses from misdirected projects that never attained their business goals.

Table 1 Example of a Work System Snapshot

Customers	Products & Services
Loan applicant Loan officer Bank's Risk Management Department and top management Federal Deposit Insurance Corporation (FDIC) (a secondary customer)	Loan application Loan write-up Approval or denial of the loan application Explanation of the decision Loan documents
Work Practices (Major Activities or Processes)	
Loan officer identifies businesses that might need a commercial loan. Loan officer and client discuss the client's financing needs and discuss possible terms of the proposed loan. Loan officer helps client compile a loan application including financial history and projections. Loan officer and senior credit officer meet to verify that the loan application has no glaring flaws. Credit analyst prepares a "loan write-up" summarizing the applicant's financial history, providing projections explaining sources of funds for loan payments, and discussing market conditions and applicant's reputation. Each loan is ranked for riskiness based on history and projections. Real estate loans all require an appraisal by a licensed appraiser. (This task is outsourced to an appraisal company.) Loan officer presents the loan write-up to a senior credit officer or loan committee. Senior credit officers approve or deny loans of less than $400,000; a loan committee or executive loan committee approves larger loans. Loan officers may appeal a loan denial or an approval with extremely stringent loan covenants Depending on the size of the loan, the appeal may go to a committee of senior credit officers, or to a loan committee other than the one that made the original decision. Loan officer informs loan applicant of the decision. Loan administration clerk produces loan documents for an approved loan that the client accepts.	
Participants	**Information**	**Technologies**
Loan officer Loan applicant Credit analyst Senior credit officer Loan committee and executive loan committee Loan administration clerk Real estate appraiser	Applicant's financial statements for last three years Applicant's financial and market projections Loan application Loan write-up Explanation of decision Loan documents	Spreadsheet for consolidating information Loan evaluation model MS Word template Internet Telephones

Note: A hypothetical loan application and underwriting system for loans to new clients.
(Source: Alter [2006])

Two basic guidelines for a work system snapshot are: (1) For purposes of the analysis, the work system is the smallest work system that has the problem or opportunity that motivated the analysis. (2) The work system's scope is not determined by the software that is used. This is why a work system should not be called a "Lotus Notes system" or an "SAP system" just because it happens to use a particular brand of software.

2.2.5 Work system snapshots vs. flow charts, use cases, and other system documentation

Work system snapshots differ in important ways from traditional business process tools and documentation methods. Unlike flow charts and UML class diagrams, sequence diagrams, or activity diagrams, work system snapshots are not particularly concerned with precise documentation of detailed logic. Instead, they focus on clarifying the work system's scope by identifying the major processes and activities, participants, information, and so on. Agreement on the work system's scope helps in clarifying the problems and opportunities that are being addressed.

Use of work system snapshots can potentially address the difficulty often encountered when business professionals and IT specialists try to collaborate in projects. Work system snapshots can help them attain a meeting of the minds about the scope of the system that is being created or improved. Staying at an overview level supports that discussion by encouraging focus on big picture issues rather than minor details that often obscure whether everyone agrees on the scope of the effort.

The straightforward format of work system snapshots, and the fact that they can be produced easily using a word processor implies that they can be used in situations where diagramming software or CASE software is not available or is impractical for non-experts to use. Use of work system snapshots in hundreds of MBA and Executive MBA assignments, plus informal reports from MBA students who used work system snapshots in their work settings, indicates that this tool can be used directly by business professionals.

In contrast, UML's technical artifacts and concepts, such as classes, objects, and use cases, make it an impractical tool for direct use by business professionals who lack extensive training. Although UML is a de facto standard in the IT industry, even there UML has proven problematic in many applications (e.g., Erickson and Siau, 2004; Dobing and Parsons, 2006, 2008). Ongoing research has started to examine the relationship between work system snapshots and use cases, starting with the assumption that each of the processes or activities in a work system snapshot might be viewed as a separate use case (Tan et al., 2008). Regardless of how that research turns out, it seems likely that systems analysis tools that are posed in everyday business language such as the terms in the work system framework (Figure 1) have a higher likelihood of successful use by

business professionals in the context of describing, analyzing, and designing systems that provide services.

2.3 Principle #3: Assume that value is co-produced with customers.

Use of the work system framework is a major step toward a service mindset for thinking and communicating about systems. It is possible to go substantially further by emphasizing the fact that every work system can be viewed as a service system because it produces something for someone. To go beyond the service-related ideas in the work system framework, it is possible to incorporate a set of generic activities and responsibilities of service providers and service customers.

2.3.1 Service value chain framework

Figure 2 shows a service value chain framework that incorporates typical categories of service activities and responsibilities. (This is an updated version of a framework that appeared previously in Alter [2007, 2008].) The bilateral form of the service value chain framework is based on the widely accepted observation that value from services is co-produced by service providers and service consumers.

2.2.3 Co-production of value

Co-production of customer value implies that the customer has responsibilities, and that customer value involves more than just receiving and using whatever the work system happens to produce. For example, the success of medical care in everyday life depends partially on the quality of the doctor's diagnosis and partially on the patient's compliance with whatever the doctor prescribes. Similarly, the success of an outsourced data center depends partly on the outsourcing vendor and partly on the company receiving the outsourcing services.

2.2.4 Other service topics and issues

The service value chain framework represents a number of service topics and issues that should be considered when thinking about any work system as though it were providing services. Starting at the top of Figure 2, part of a service system's success depends on the existence of prerequisite systems, on awareness that the service is being offered, and on the negotiation of governing commitments such as service level agreements. Within specific service instances (lower in Figure 2) it is often useful to consider generic steps such as customer and provider preparation, specification and negotiation of service requests, the process of service fulfillment, and any necessary follow-up. All of the generic steps involve service interactions. Ideally the service design should have the right balance of front-stage and back-stage activities for both the service provider and the customer. It is worthwhile to consider value capture by both the

customer and provider throughout the service value chain. For example, part of the value in some service processes is that the provider and customer have a mutually beneficial service level agreement and do not need to re-negotiate with each instance of providing the service.

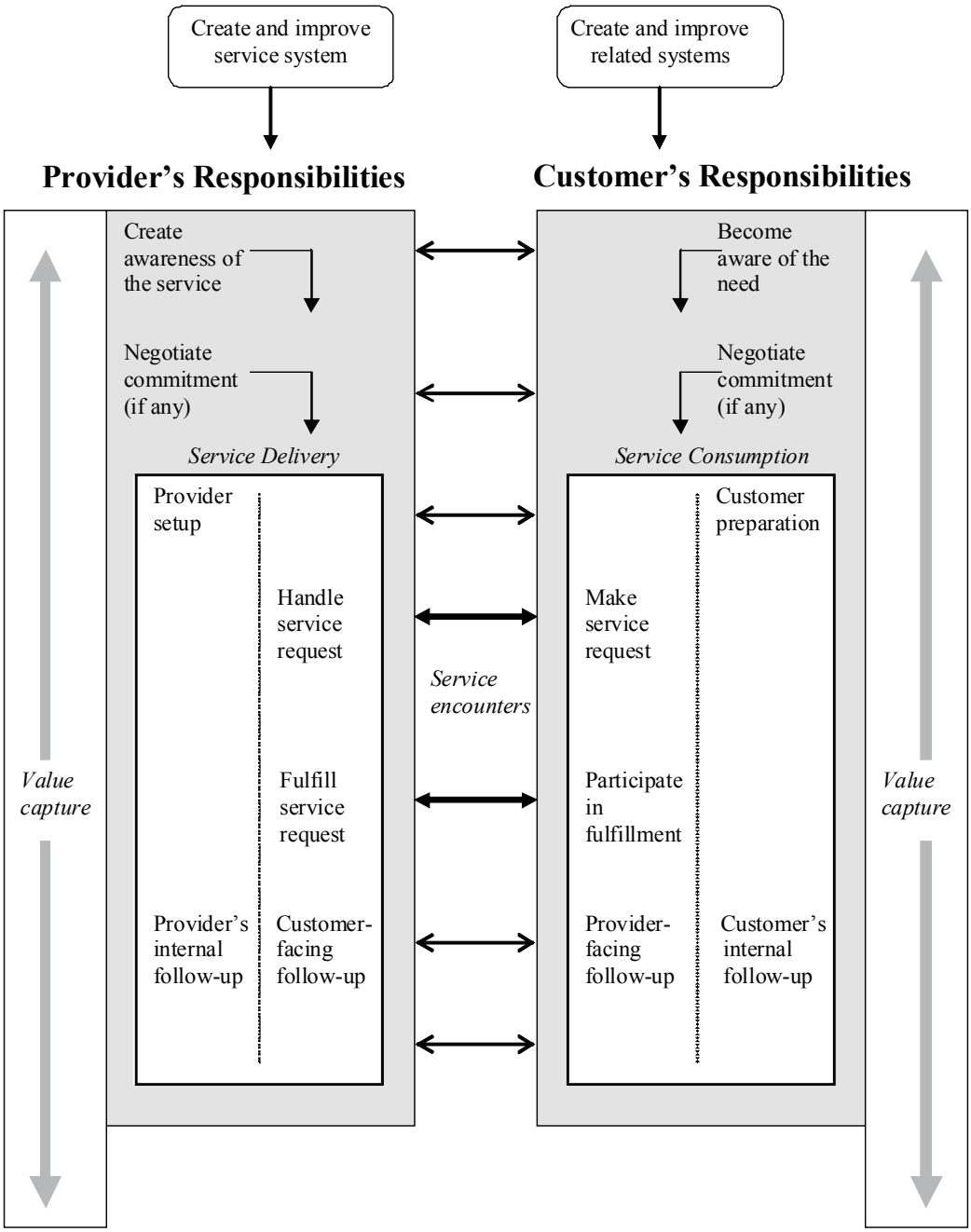

Figure 2 Service Value Chain Framework
(Updated from Alter [2007, 2008])

Adopting a service mindset in thinking and communicating about systems in organizations calls for considering topics such as those represented in Figure 2. Most of those topics are not included in any explicit way in typical systems analysis methods or tools.

2.3.4 Service responsibility tables

Assuming that services are co-produced, the core of a service process can be summarized using a service responsibility table (SRT), a two-column swimlane diagram with one column identifying provider responsibilities, with a second column identifying corresponding customer responsibilities, and with specific provider and customer roles indicated clearly. If there is an intermediary, such as a purchasing agent who links customers and suppliers, it is often useful to include three swimlane columns.

Use of a two-column SRT early in the analysis of a work system that produces services accomplishes several purposes.

1. It clarifies the scope and context of the work system without requiring research about the detailed logic of workflows. For this purpose, it is much simpler to produce and use than a flowchart or other graphical form of representation (which will be needed later in the analysis to clarify detailed logic and other specifics that are not essential for an initial understanding).
2. It focuses attention on activities and responsibilities, rather than on details of technology and information.
3. It identifies the job roles that are involved.
4. It brings customer responsibilities into the analysis.
5. It identifies steps involving provider-customer interactions (rows with both provider and customer responsibilities) and other steps that are not visible to customers.

As the analysis continues, it is easy to add one or two additional columns to an SRT or to use a series of SRTs that address different aspects of the analysis while framing the SRT user's attention around the steps in the first two columns. Table 2 contains a 3-column SRT that identifies problems and issues related to specific steps. Other possibilities for additional columns focus on topics such as preconditions and post-conditions, business rules, important exceptions, common errors, information used, and performance gaps. Many other possibilities are summarized in Alter (2008).

2.3.5 Extending the work system framework's emphasis on the customer

The service value chain framework (Figure 2) and the idea of SRTs (Table 2) were proposed too recently to have completed research demonstrating their impact on systems

analysis. For now, the main point in both cases is that they extend the work system framework's emphasis on the customer. The work system framework puts the customer at the top and allows the customer to be a participant if appropriate. Going a step further, both the service value chain framework and SRTs are based on co-production of value by providers and customers. They assume that customers participate actively or passively in at least some of the activities in service provision. They also assume that that participation must be included in a thorough description or analysis of a system that provides services.

It is an open question about whether and how customer activities and responsibilities are usually reflected in real world systems analysis efforts that do not have an explicit emphasis on co-production of value. For example, UML use cases are basically about uses of computerized tools, typically from a provider viewpoint rather than from a customer viewpoint, and therefore do not go very far in that direction. Six Sigma tools often refer to the "voice of the customer", but that is usually about understanding customer wishes and needs, rather than assuming that customers play active roles in co-producing value within service systems. Until empirical research results are available it is only possible to say that the service value chain framework and SRTs provide a means for greater emphasis on customer activities and responsibilities that may matter a great deal in service success. For now, the conclusion is that managers and analysts who are concerned about service effectiveness may want to use those ideas to explore co-production issues that might otherwise be ignored.

Table 2 Three-Column Service Responsibility Table (SRT) for the Loan Example in Table 1

Provider Activity or Responsibility	Customer Activity or Responsibility	Problems or Issues
Loan officer identifies businesses that might need a commercial loan.		Loan officers are not finding enough leads.
Loan officer contacts potential loan applicant.	**Potential loan applican**t agrees to discuss the possibility of receiving a loan.	
Loan officer discusses loan applicant's financing needs and possible terms of the proposed loan.	**Potential loan applicant** discusses financing needs.	Loan officer is not able to be specific about loan terms, which are determined during the approval step, which occurs later.

Table 2 Three-Column Service Responsibility Table (SRT) for the Loan Example in Table 1 (Continued)

Loan officer helps loan applicant compile a loan application.	**Loan applicant** compiles loan application.	Loan applicant and loan officer sometimes exaggerate the applicant's financial strength and prospects.
Loan officer and **senior credit officer** meet to verify that the loan application has no glaring flaws.		20% of loans applications have glaring flaws.
Credit analyst prepares a "loan write-up" summarizing the clients' financial history, providing projections of sources of funds for loan payments, etc.		10% rate of significant errors, partly because credit analysts use an error prone combination of several spreadsheets and a word processing program. Much rework due to inexperience of credit analysts.
Loan officer presents the loan write-up to a senior credit officer or loan committee.		Meetings not scheduled in a timely manner. Questions about exaggerated statements by some loan officers.
Senior credit officer or **loan committee** makes approval decision.		Excessive level of non-performing loans. Rationale for approval or refusal not recorded for future analysis.
Loan officer informs loan applicant of the decision.	**Loan applicant** accepts or declines an approved loan.	25% of refused applicants complain reason is unclear. 30% of applicants complain the process takes too long.
Loan administration clerk produces loan documents for an approved loan that the client accepts.		

(Source: S. Alter [2007], 'Service Responsibility Tables: A New Tool for Analyzing and Designing Systems', *Proceedings of AMCIS 2007*, Americas Conference on Information Systems, Keystone, CO. Reprinted in Alter [2008].)

2.4 Principle #4: Think of projects as work system projects rather than IT projects.

From a business viewpoint, projects that attempt to improve the way work is performed should be viewed as work system projects, not IT projects, unless they focus totally on technical infrastructure. Taking a work system approach calls for a life cycle model that describes how work systems evolve.

2.4.1 Work system life cycle model

A work system evolves through iterations of planned and unplanned change. The work system life cycle model (WSLC) in Figure 3 describes how work systems change over time. The planned changes occur through formal projects with initiation, development, and implementation phases. The unplanned changes are ongoing adaptations and experimentation that change aspects of the work system without performing formal projects.

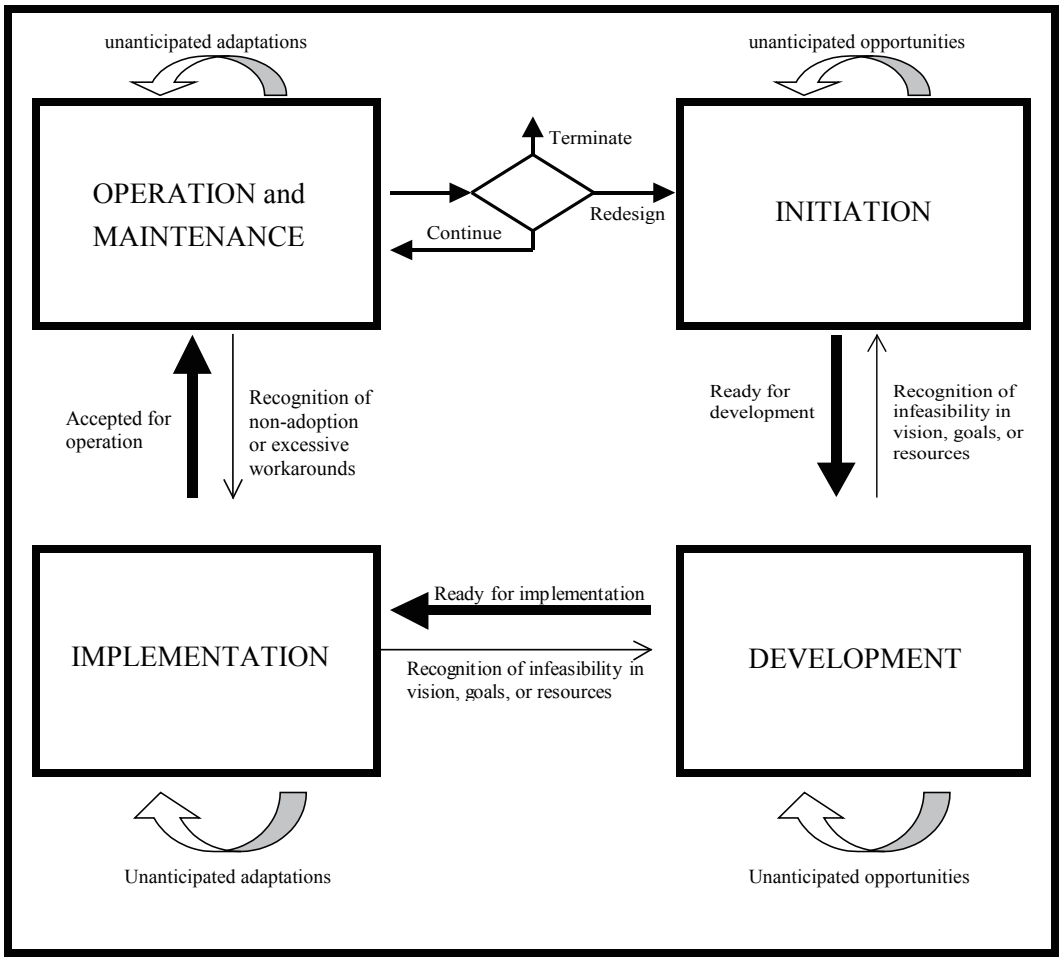

Figure 3 The Work System Life Cycle Model (Source: Alter [2006])

The WSLC is fundamentally different from the frequently cited system development life cycle (SDLC). First, the SDLC is basically a project model rather than a system life cycle. Some current versions of the SDLC contain iterations, but even those are basically iterations within a project. Second, the system in the SDLC is basically a technical artifact that is being programmed. In contrast, the system in the WSLC is a work system that evolves over time through multiple iterations. This evolution occurs through a combination of defined projects and incremental changes resulting from small adaptations and experimentation. In contrast with control-oriented versions of the SDLC, the WSLC treats unplanned changes as part of a work system's natural evolution.

2.4.2 A service mindset for viewing projects

The WSLC reflects a service mindset in several ways. Consistent with principles #1 and #2, it focuses on the work system, rather than the IT system, thereby emphasizing things that business professionals care about, namely, improving the form, function, and performance of one or more work systems, rather than just creating or installing software. Focusing on work systems also maximizes the likelihood that business professionals will be able to comment knowledgably about analysis, design, and implementation issues. Its work system emphasis is also consistent with principle #3 because work system projects necessarily involve co-production of value by business and IT professionals. Work system projects require business/IT coordination because the projects cannot stay on track without attention from business professionals and cannot succeed without technical capabilities provided by IT professionals.

Thinking of a project as a work system project necessarily implies co-production of value by business and IT professionals across all four stages of the WSLC in Figure 3.

2.4.2.1 Operation and maintenance phase

Business professionals manage the work system, including continuous improvement unrelated to IT. Business and IT professionals share the responsibility of monitoring alignment between IT capabilities and work system needs, and coordinating continuous improvement related to IT capabilities. IT professionals maintain hardware and software.

2.4.2.2 Initiation phase

Business professionals define business problems and goals, priorities, constraints, and success criteria. Business and IT professionals outline the general approach for addressing problems and attaining goals. They are also responsible for agreeing on organizational and economic feasibility of the project and for producing the initial project plan for improving the work system. IT professionals identify how IT can contribute and define IT-related goals for the project.

2.4.2.3 Development phase

Business professionals work with business and IT analysts to specify how the improved work system should operate. Ideally, they should evaluate the usability of hardware and software and should participate in debugging of application features and user interfaces. Business and IT professionals are jointly responsible for determining detailed requirements for the work system and user-visible features of IT capabilities. Ideally, they should agree that hardware and software are ready for implementation in the organization. IT professionals acquire, develop, modify, and debug hardware, software, and documentation.

2.4.2.4 Implementation phase

Business professionals manage implementation in the organization, and monitor both acceptance and resistance. Whether or not they are involved in training on IT details, they should be involved in training on new work practices and in assuring the success of aspects of conversion that are unrelated to IT capabilities. Business and IT professionals have joint responsibility for keeping the implementation on track, deciding whether additional IT modifications are needed, converting to new work practices that involve IT, and verifying that the implementation is successful. IT professionals modify hardware and software as needed for successful implementation.

2.4.3 Comparison with other life cycle models

The work system life cycle model differs from most life cycle models in the IS field because it describes the iterative life cycle of a work system rather than the idealized progression from the beginning to the end of a software project. It also differs from a variety of models related to process and organizational change and reengineering (e.g., Harrington, 1991; Davenport, 1993; Kettinger et al., 1997). The latter models tend to cover many of the same steps as the work system life cycle model, but tend to say less about software development. For example, the steps in Harrington's (1991) model of business process improvement include organize for improvement, understand the process, streamline the process, measurements and controls, and continuous improvement. Davenport's (1993, p. 25) major steps in process innovation include identify processes for innovation, identify change levers, develop process visions, understand existing processes, and design and prototype new processes. The stages in Kettinger et al.'s (1997) business process reengineering framework include envision, initiate, diagnose, redesign, reconstruct, and evaluate. In contrast, the development phase of the work system life cycle model is explicitly devoted to developing whatever resources are required for successful implementation in the organization.

3. Steps toward a deeper service mindset

Adopting a deeper service mindset requires methods and concepts for communicating and thinking effectively about IT-reliant systems in organizations. Principle #1, interact with business professionals around business topics that they care about, leads directly to principle #2, see "the system" as a work system, not and IT system. Incorporating service concepts in more depth calls for principle #3, assume that value is co-produced with customers. In turn, principles #1, #2, and #3 lead to principle #4, thinking of projects as work system projects, not IT projects.

It is possible that use of the three frameworks derived from these principles could help in improving currently disappointing levels of user involvement and business/IT alignment. These frameworks have been tested in classroom settings and have received informal testimonials from employed students (e.g., "I am using it to help in my software sales cycles." or "It helps me explain what I need."). Most recently, advanced MBA students (averaging six years of business experience) at Georgia State University have submitted over 150 analyses and recommendations related to work systems in their own organizations. Although the analysis of those submissions has only begun, the initial summary results demonstrate that business professionals can use the work system framework and work system snapshot effectively for thinking about service systems in their own organizations.

The evaluation of those papers by two reviewers found that most students produced understandable and at least reasonably well argued reports even though they received relatively little documentation of work system concepts and prior work system examples, and even though this assignment was only part of the workload from an evening MBA course for individuals who were already working 40 or more hours per week. Most of the submissions recognized the desirability of starting the analysis without assuming that automation or computerized support of processes should be the goal. Most recognized the necessity of understanding the business situation, describing business issues, and thinking about possibilities for change. In classroom discussions the students unanimously agreed (i.e., there were no dissenting views) that the analysis outline was valuable for promoting organized communication and inquiry about the work system they were analyzing.

There are two possible approaches for using this article's ideas for adopting a deeper service mindset for thinking and communicating about systems. The more conservative 4-step approach starts by assessing the current state of business/IT collaboration (steps #1 and #2 below). The more aggressive approach starts with step #3 below, and moves directly toward initial usage of a work system approach.

3.1 Assess the current state of frameworks, terminology, and methods used when collaborating with business professionals

Many organizations use general-purpose methods such as cost/benefit analysis and SWOT (strengths, weaknesses, opportunities, threats) analysis. Although these are fine in their own terms and should not be abandoned, their core topics are primarily financial and/or competition-related, and may not incorporate a service mindset. If user involvement in IT-related projects is a problem in your organization, it is worthwhile to see whether the frameworks, terminology, and methods used in those projects genuinely support a service mindset. It is also worthwhile to see whether business professionals are familiar enough with business-oriented frameworks, terminology, and methods to be able to use them without direct assistance from business or IT analysts.

3.2 Assess whether frameworks, terminology, and methods may have been a factor in past disappointments

Look at past projects that were supposed to improve work system performance but turned out to be disappointments or disasters. How well did business professionals understand project goals, project scope, and desired changes in work practices before software was acquired or built? Was the project viewed as an IT project rather than a work system project? Did project communications and documentation fully recognize the differences between the work systems that were to be supported and the technical tools that were being built or improved?

3.3 Produce and test a draft of frameworks, terminology, and methods that seem appropriate for your organization

Start small. Identify ideas and terminology that fit with your organization. This article's frameworks and ideas might be a starting point, but some of the terminology might be changed to fit other terminology in your organization. Make sure that common words such as system, user, and implementation do not have multiple, inconsistent meanings. Make sure IT participants in a project are fluent in the new approach and then use it in the early stages of a project aimed at business process improvement.

3.4 Take steps toward institutionalizing your approach

Build on learnings from the initial pilot. Obtain feedback from business and IT participants about aspects of the new approach that were or were not effective. Develop an improved version of your approach and try it in another project. See whether the quality of user involvement improves.

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Steven Alter is a Professor of Information Systems at the University of San Francisco. He received his B.S. and Ph.D. at MIT. His research for the last decade has concerned developing systems analysis concepts and methods that can be used by typical business professionals and can support communication with IT professionals. His 2006 book, The Work System Method: Connecting People, Processes, and IT for Business Results, is a distillation and extension of ideas in 1992, 1996, 1999, and 2002 editions of his information system textbook. His articles have been published in Harvard Business Review, Sloan Management Review, MIS Quarterly, IBM Systems Journal, European Journal of Information Systems, Communications of the Association for Information Systems, Communications of the ACM, and other journals and conference proceedings.

MIS Review Vol. 15, No. 2, March (2010), pp. 55-73

A Symbiosis-Based Value Co-Creation Framework for Service Delivery Design

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ABSTRACT: *This paper proposes a service delivery design framework as a means-end tool for modeling, designing, and developing the service systems (e-service) which can fulfill (semi-)automated value co-creation between the service providers and the customers. In order to achieve the goal of service innovation, this study arise concerns how an innovative e-services can be systematic service process according to the proposed service delivery design framework. However, the framework takes into account a novel service delivery classification and individual criteria. In this paper, either service delivery classification or the counterparts of service performance measures emerged from the ecological symbiosis perspective through analytic and synthetic methods. The proposed service delivery design framework defines two dimensions -- continuity of co-creation and mutual adaptability -- characterized by the process of exchanging service/benefit and building relationship (i.e., partnership) involved within a service. The framework indicated that how the interactions and the service/benefit exchange between the service provider and the consumer can conduct in a service delivery process. To build partnership by the service participants due to mutual adaptability whose they adapt to the counterpart of service (i.e., the service provider or the customer). This paper accordingly classifies the six categories of service delivery based on ecological symbiosis perspectives. To examine individual service performance is derived from a set of criteria of species' performance measures in ecological mutualism including proximate response, evolved dependence, and ultimate response. The service delivery systems comply with the characteristics and criteria in the framework to demonstrate the sets of methodology for innovative service delivery design.*

KEYWORDS: *Service Delivery Innovation, Value Co-creation, Classification, Service Delivery Design Framework, Service Performance, Mutualism, Collaboration.*

1. Introduction

Service systems, in general, are made up of large numbers of interacting consumers and producers who co-produce value. The dynamics of their interactions are driven by the constantly shifting value of knowledge distributed among consumers and producers, evolving in difficult to predict ways. Consequently, the design of service systems driving

innovation is generally regarded as a very challenging problem (IBM, 2005). For the purposes of this research, service innovation refers to invented service system designs yielding value in solving real service problems, where such value is toward maximum customer satisfaction and service productivity.

A service system (e-services) can be viewed as an eco-system. Thus, the superior relationship between the service provider and the customer is similar with the relationship among the species when they increasingly evolved the partnership as mutualism (i.e., symbiosis). In order to achieve the advancement in the partnership, the study presents a service delivery design framework, aimed at classifying six categories of invented service delivery design. Either a service provider or a customer interacts with the counterpart of partner to value co-creation within a service delivery. The framework is able to facilitate to build a superior partnership to co-produce collaborative service through a service provision and service encounter in the novel service systems.

In the service delivery design framework, either "continuity of value co-creation" or "mutual adaptability" can be characterized by the service/benefit exchange and build the relationship such as collaborative and mutualism. The dynamic relationship between the providers and the customers is relatively complex; consequently, we fix the problem using the evolutionary concept (e.g., adaptation and evolution) and the emerging technologies. To design a service system outlines in "intelligent service delivery design" in the sense that designers are aware of the ecological symbiosis between the partners. Although the service delivery design framework is potentially applicable to a variety of service industries, the artwork design industry can be used to fulfill and implement the characteristics and concepts of ecological symbiosis we adopted. For example, three service delivery systems (e.g., interior design, industrial design and entertainment design) in this study can be demonstrated by applying the service delivery design framework to describe how service participants can achieve the collaboration and symbiosis.

The remainder of this article consists of five sections. Section 2 describes the migration behind the service economy, service/benefit exchange, services innovation for the artwork design industry. Section 3 presents an approach to classifying services and individual criteria. Section 4 provides three scenarios to exemplify the concept of symbiotic and collaborative e-services. Section 5 discusses the managerial implications of this research. Concluding remarks are presented in Section 6.

2. Background

The service sector is becoming increasingly important to the economies of many countries, especially developed countries, where services account for a dominant

percentage of economic activity (Lusch, et al., 2008). However, the rapid growth in services is also being seen in developing countries. The Organization for Economic Co-operation and Development (OECD) recently released its report "Promoting Innovation in Services," which noted that government policy in developed countries has not been attuned to the service sector (Bitner and Brown, 2006).

Recently, Steven and Paul (2006) wrote a significant attention has been drawn to a new research area of services science that applies insights from scientific, management, and engineering (SSME) and scientific, management, engineering, and design (SSMED) (Spohrer and Kwan, 2009; Glushko, 2008) perspectives to analyze how to align people and technology effectively to generate value for both services providers and clients. IBM (2005) discussed the objective of service science includes such issues as management of service innovation and restructuring of organizations. Other important aspects of service science pointed out that co-creation and sharing of value through the collaboration of firms and suppliers, research into the capabilities of business and government to create improved value, evaluation of the information technology and tools, and investigation of enterprise culture for the encouragement and convergence of employees as well as the totality of services effectiveness. Chesbrough and Spohrer (2006) identify several elements of a foundation for this research area: (1) close interactions of suppliers and customers; (2) nature of knowledge created and exchanged; (3) simultaneity of production and consumption; (4) combination of knowledge into useful systems; (5) exchange as processes and experience points as well as (6) exploitation of ICT and transparency. In the other words, this study showed that "how might a service scientist approach the problem of creating service innovations and improving the service system?"

In order to meet the consumer's needs, Heskett (2003) wrote the service providers now attempt to add or create value through services. According to Prahalad and Ramaswamy (2004), two paradoxes dominate the future of competition in services: consumers face choices that yield less satisfaction, while managers face more strategic options that yield less value. However, the traditional e-service should be re-examined, this research address the arguments that how to be the advancement in value co-creation through emerging technologies (e.g., adaptive technologies) and system architecture (e.g. SOA).

2.1 Service exchange for value co-creation

With the properties of services sector, they are different from the goods-producing sector. A service delivery can be view as the course of value co-creation between the provider and the customer. The service providers utilize the capabilities to fulfill the task of services for the customers during a service process. In other words, the way to exchange service/benefit represents how the service participants deal with the responsibilities, capabilities, and benefits to fulfill value co-creation. Steven and Paul

(2006) describe a service also involves people in terms of (1) building and maintaining relationships and (2) understanding the interface between people, business strategy, business processes, and technology). Thus, building the superior relationship could be useful to value co-creation among service participants.

A service has a number of unique characteristics that tangible products often lack. Vermeulen et al. (2001) describe services are intangible, co-produced between the providers and the customers, perishable, experienced, and heterogeneous. With the difference in service production process, customers co-production were accommodated in production process, production setting and production employees besides co-producers (Bowen and Ford, 2002). For emerging service-centered dominant logic, people exchange acquire the benefits of specialized competences (knowledge and skills), or services in Vargo and Lusch (2004). Normann and Ramirez (1993) have pointed out that services cover all activities in which obtaining actual utility value requires customer value creation. The link between actions by supplier and customers they termed "offerings." Ramirez, (1999) indicated that business definition can study how economic actors (1) design new offerings, joining actors in innovative co-productive relationships; (2) reconfigure the roles each co-producer holds in relating to others, and (3) new value creation systems. In concerning co-production view, value is co-produced, with customer, over time -- for both co-producers (relationship). The effects of service delivery through a service process result from the service/benefit exchange and value co-creation among service participants within a service encounter.

A service system composed of subsystems/components which refer to the value co-creation productively or uniquely. To facilitate the development of service systems with value co-creation (Payne at. al., 2008) is crucial to ensure superior service delivery. Such collaborative e-services can be certainly facilitated by intranets, extranets, and internet. Furthermore, the adaptive techniques (e.g., genetic algorithms) are especially appropriate for dealing with co-production and customization issues in James and Daniel (2003). In this study, an innovative service system for transformative processes are further examined, in light of the fact that service innovation can be driven by information technology to identify the advantage of value co-creation. Estimating value in service systems, Caswell et al., proposed a descriptive structure for the analysis of this complexity which combines graph theory and network flows with economic tools (Caswell et. al., 2008). Accordingly, IT has given providers and customers access to the support of collaboration in service provision and service delivery. Service participants build the relationship as partner (i.e., symbiosis) to create the value co-creation. The flexible relationship is associated with the relationship between the customer and the producers. This framework takes into account the two dimensions, value co-creation continuity and mutual adaptability to facilitate the service delivery design.

2.2 Services innovation for design industry

In order to demonstrate intelligent service delivery design, artwork design industry can be used to be the example to showcase the service delivery design underlying ecological sysmbiosis. Cooper and Press (1995) observed that artwork design is at once an art, a problem solution, a creative behavior, a collected specialization, and an industry. Walsh et al. (1992) viewed artwork design as an activity and a result of an activity, activities as a design procedure, the results of activities as ideas, as a plan of principle parts that can be made, or as a plan of the type of principle part. Design scholars, Ulrich and Eppinger (1995), proposed the artwork design development concept from the perspective of artwork designers including (1) confirming requirements from customers; (2) creating specifications of the objective; (3) developing the concept of production; (4) selecting the concept of production and (5) modifying specifications for the market. Hickey and Siegel presented "a case study involving a provider of IT infrastructure services and solutions and the business context of the service provider, its approach to the analysis of the requirements of multiple standards, process integration efforts, and the reuse of documentation and other evidentiary data in the context of obtaining certificates of registration or certifications." (Hickey and Siegel, 2008) In this study, the service systems of artwork design services can be a demonstration of (semi-)automated value co-creation and ensure the service productivity and customer satisfaction.

3. Intelligent service delivery design

Intelligent service delivery design is a novel service delivery design framework for systematic service innovation based on the ecological symbiosis concept. Ecology is a science that examines the interrelationship of organisms, their environments, and how organisms adapt to their environments. From the standpoint of ecology, there are different levels of viability under which organisms adapt in response to changed circumstances. For instance, the population of organism might be eliminated due to environmental change or competition. Intelligent service delivery design uses ecological symbiosis concepts to model the interactions between the customers and the suppliers in service/benefit exchange to fulfill value co-creation.

3.1 Research method

Intelligent service delivery design aims at presenting a framework for a new delivery in service delivery design and service systems. These are regarded as artificial artifacts encompassing both natural and goal-dependent phenomena, represented respectively by concepts of symbiosis from ecology and value co-creation. Our research method is based on the principles of "science of the artificial," i.e., the science (analytic) of engineering (synthetic) in Simon (1969). An artifact, in general, embodies two perspectives -- analytic

(or descriptive) and synthetic (or prescriptive). Being synthesized, the artifact can be characterized in terms of functions, goals, and adaptability, and is often discussed in terms of both imperatives and descriptives. Fulfillment of purpose involves a relation between the artifact, its environment and a purpose or goal. One can view the artifact as the interaction of an inner environment (internal mechanism), an outer environment (conditions for goal attainment) and the interface between the two. Such artificial artifacts enable to account for the service systems (e-services) in this study.

This research addressed an intelligent service delivery design using design science. According to the proposed framework, the service systems were implemented by simulation. In this paper, an up-to-date service system is regarded as the inner environment (awareness/intelligence of the scientific model of symbiosis), an outer environment (conditions of customers and suppliers in terms of the degree of continuity of co-production and mutual adaptability during value co-creation), and the interface defined as the fulfillment of service innovation by a variety of intelligent service delivery design components (Figure 1), guaranteeing the goal performance criteria (Figure 3).

3.2 Service/benefit exchange as symbiotic relationship

In symbiotic relationship, the certain species exhibit mutual dependence according to the natural phenomena of the ecological system. For instance, communalism exhibits the least extent of mutually beneficial interactions between species seeking optimal benefit utilizing a natural resource in Caroline and Gross (2000). Mutualism is defined as a reciprocally beneficial interaction between different organisms. Such symbiotic relationships frequently involve the exchange of nutrients or certain services such as the protection from enemies or transportation in Zeithaml (1981). These dependency relationships could be further detailed as follows:

- Mutualism: Mazancourt (2005) introduce this is a mutually beneficial interaction between individuals of two species. Also, mutualism is commonly divided into obligatory mutualism and non-obligatory mutualism:
  - (1) Obligatory mutualism: Two species must be cooperation; otherwise, they cannot survive. Their mutualism is permanent and obligatory.
  - (2) Non-obligatory mutualism: Two species have benefits each other when they can be cooperation, but their fixed role for cooperation is unnecessary.
- Commensalism: Although two species can be cooperation, only one-sided has benefit.

Wu (2003) wrote Mutualism and Commensalism have been investigated group and organization research. System, cycle, network, hierarchy (and the particular role of organisms in those structures) become the basis for the scientific work focused on the

concept of ecosystem in Leydesdorff (2006). A certain number relationships between producers and customers are characterized by symbiosis. In terms of service/benefit exchange, both providers and the customers are involved in shaping the continuum of value co-creation (i.e., mutualism/collaboration/commensalism). The interactions between providers and customers were deemed the cooperation as addressed in the ecological symbiosis. Moreover, the providers and the customers are engaged in adapting their behaviors and developing their flexible relationships during the service/benefit exchange process. The adaptation of behaviors and flexibility account for "the degree of mutual adaptability" (i.e., "one-sided" represents customer or provider; "two-sided" represents customer and provider). Mazancourt, Loreau, and Dieckmann (2005) discuss the three levels of service/benefit exchange are defined -- commensalism, collaboration, and mutualism -- commensalism refers to slight symbiosis, collaboration refers to a medium symbiosis, and mutualism refers to full symbiosis.

3.3 Service delivery classification underlying evolution and adaptation in ecology

This section presents a framework for classifying the service delivery design using the concepts of symbiosis. The framework of service delivery design includes six quadrants, each of which is associated with certain properties in service/benefit exchanges to fulfill systematic service innovation. The details of the two dimensions of framework as following:

- Continuity of value co-creation:

  The three types of evolutionary phenomenon -- obligatory mutualism, non-obligatory mutualism, and commensalism -- in the symbiosis of ecology.

  (1) Mutualism: mutually beneficial interactions between the providers and the customers. The specific partner (i.e., it's a fixed relationship between the provider and the consumer) is necessary for the value co-creation.

  (2) Collaboration: mutually beneficial interactions between the providers and the customers. Comparing with mutualism, the specific partner is unnecessary (i.e., it's not a fixed relationship between the provider and the customer) for value co-production.

  (3) Commensalism: one-sided (provider or customer) has the benefit when they build the symbiotic relationship.

- Degree of mutual adaptability:

  In order to identify the type of adaptability displayed in the interactions of the providers and the customers in service/benefit exchange. The dimension of mutual adaptability derives from the well-known evolution underlying modern

ecology that describes adaptation of organisms to their environment (i.e., Darwin's evolution theory). Two types of mutual adaptability involve:

(1) One-sided adaptability: either the providers adapting to the customers or the customers adapting to the providers.

(2) Two-sided adaptability: enabling high flexibility in changing the objectives of the partnership.

Considering continuity of value co-creation and the degree of mutual adaptability, the framework identifies a variety of interactions in the process of services/benefit exchange (as shown in Figure 1).

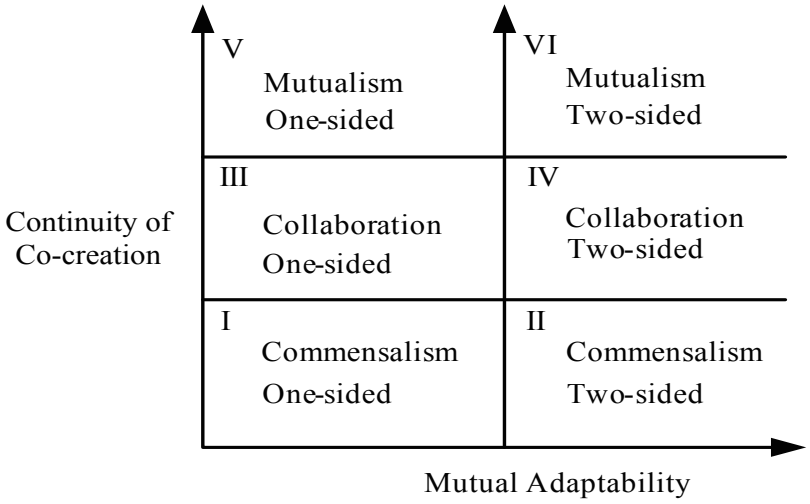

Figure 1 Classification Framework

This framework has been demonstrated through the three service systems featuring mechanisms of (semi-)automating the service/benefit exchanges denoted by IV, V, VI of Figure 1. The service systems interpreted by the scenarios in the diverse artwork design industry respectively.

3.4 Measuring service delivery performance from measuring mutualism's performance

Rust et al. (2006) wrote productivity and satisfaction are not always mutually compatible goals, especially in the service sector. According to the symbiosis perspective, a mutualism is a mutually beneficial interaction between individuals of two species. To identify continuity of value co-creation and mutual adaptability can be addressed in this framework. We can apply the notions of symbiosis performance in monitoring mutualism to the interactions of service/benefit exchange between the providers and the consumers. As a result of the measures of service performance, a service delivery design platform

also should provide a mechanism of performance measurement which devised for (semi-) automation of the service/benefit exchanges with specified performance criteria

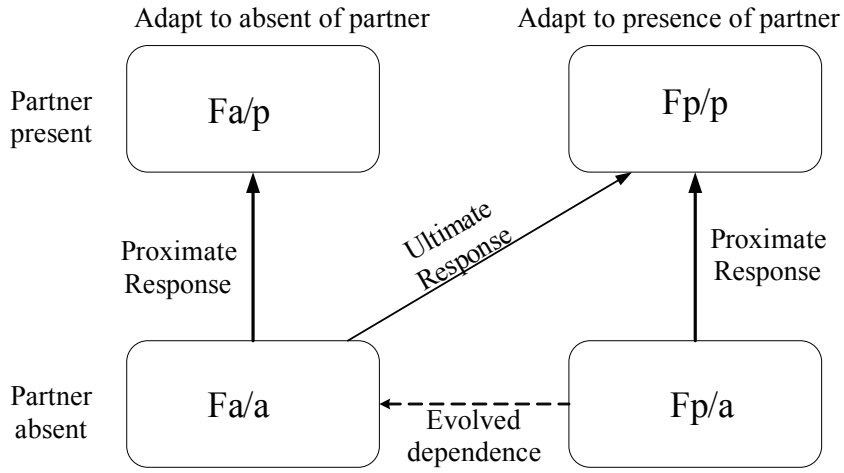

Figure 2 Performance Difference for Proximate Response, Evolved Dependence, and Ultimate Response

Mazancourt, Loreau and Dieckmanu (2005) describe the three different criteria derived from ecology can be used to test for performance of mutualism (Table 1):

Table 1 Definitions of Criteria Items

Criteria item	Definition
Proximate Response (PR)	The difference in performance of a genotype before and after short-term removal (or addition) of the partner species. That is, proximate response aims to understand whether the performance of the same genotype with the partner performs better than that without partner.
Ultimate Response (UR)	The performance, in the partner's presence, of a genotype adapted to the partner, is compared with the performance, in the partner' s absence, of another genotype adapted to this absence. The ultimate response aims to understand whether the focal species performs better than it would have done without the other species.
Evolved Dependence (ED)	This measures the performance difference between the performance without the partner of a genotype that evolved without the partner and the performance without the partner of a genotype that evolved with the partner. Evolved dependence measures the loss of performance of a focal population in the absence of a partner due to its adaptation to the presence of the partner.

To identify the partner in a service, a provider can be viewed as a partner for a customer (versus for a customer can be a partner for a provider). Figure 2 depicts the three criteria (proximate response, ultimate response, and evolved dependence) represented in terms of the methods of performance measurements associated with the service performance between the providers and the customers:

Table 2 Equations of Criteria

Criteria	Definition	Equation
PR Criteria	measuring the proximate response of a provider to the removal of its partner in terms of the performance deviation (shown in Figure 2 by a single solid line)	$F_{p/p}$- $F_{p/a}$ (ie., PR_p) $F_{a/p}$- $F_{a/a}$ (ie., PR_a) where $F_{p/p}$ denotes the performance measure of the customer with partner present, $F_{p/a}$ is the performance measure of the customer with partner absent, the proximate response of the customer to partner addition is measured as $F_{p/p}$- $F_{p/a}$ for the customer adapting to the partner presence. The proximate response of the customer to partner absent is measured as $F_{a/p}$- $F_{a/a}$ for the customer adapting to the partner absence.
UR Criteria	Measuring the performance, in the partner's presence, of a provider adapted to the partner, is compared with the performance, in the partner's absence, of the customer adapted to this absence in terms of the performance deviaiton (shown in Figure2 by a single double line).	$F_{p/p}$- $F_{p/a}$ (ie., $UR_{p/a}$) where $F_{p/p}$ is the performance measure of the customer with partner present, $F_{p/a}$ denotes the performance measure of the provider with partner absent The ultimate response of the customer to partner removal is measured as $F_{p/p}$- $F_{p/a}$, representing the difference between the performance in the presence of the partner of a customer that evolved with the partner and the performance in the absence of the partner of a provider that evolved without the partner.
ED Criteria	Measuring the performance deviation between the provider that adapted to the partner's absence and the customer that adapted to its presence, both measured in the absence of the partner by performance difference (shown in Figure 2 by a dotted line).	$F_{a/a}$- $F_{p/a}$ (ie., ED_{ap}) where $F_{a/a}$ is the performance measure of the provider with partner absent, $F_{p/a}$ is the performance measure of the customer with partner absent. Evolved dependence is measured as the difference between the performance without the partner of a customer that evolved without the partner and the performance without the partner of provider (Figure 2).

4. Service delivery systems as demonstration

This study specifies the three services for artwork design relative to the characteristics of quadrant IV, V and VI respectively (Figures 1). Each of the artwork design services displays characteristics of the continuity of co-production and mutual adaptability. This pioneer study may make an important contribution in laying the groundwork for understanding how a platform of artwork design service provides value service innovation (as shown in Figure 4).

4.1 Measuring service delivery performance with criteria

In this section, we propose the three scenarios to further illustrate the design, model and development of artwork design e-services, including the elements of continuity of co-production and mutual adaptability as well as the criteria of performance (as shown in Figure 3):

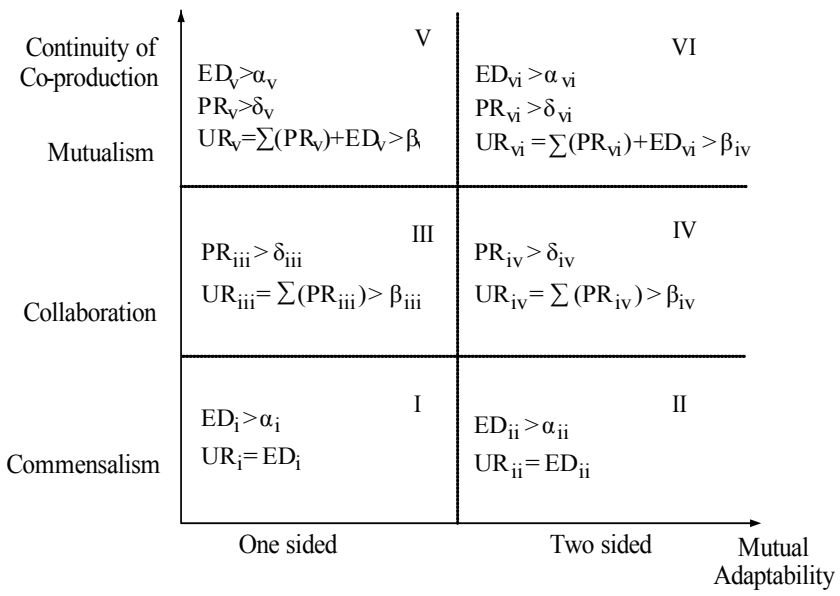

Figure 3 Performance Criteria in the Framework of Service Delivery Design

Figure 3 and Table 3 show the criteria of service performance for the collaboration and mutualism e-services. PR estimates the fitness of each service interaction, which service participants co-create the artwork in the design service. UR estimates the fitness of entire service over time. ED estimates the probable loss performance derived from the partnership change. The threshold value of PR, UR or ED ($\alpha_i \beta_i \delta_i$) respectively depends on the context of service delivery design.

Table 3 List of Thresholds Used in Figure 3

Threshold	Illustration
α_i	The threshold (α_i) of ED criteria met (greater than) qualifies for quadrant, *i = i, ii,...iv*
β_i	The threshold (β_i) of UR criteria met (greater than) qualifies for quadrant, *i = i, ii,...iv*
δ_i	The threshold (δ_i) of PR criteria met (greater than) qualifies for quadrant, *i = i, ii,...iv*

4.2 Service delivery systems scenario

4.2.1. E-entertainment

The trend of "open source" for design work implies that it might be a smart move to collect a variety of creative notions from any person who wants collaborate for value co-creation. Much artwork design in the entertainment field, such as music composition or movie production can be undertaken collaboratively by integrating many sources of materials. This service delivery system constructed of the three service components including "ontology developer," "partnership matcher" and "value appraiser" (Figure 4). However, it is unnecessary for each person involved in the work to engage cooperatively with the specific partners. Any person who is involved in co-production is non-specific partner. E-entertainment design can thus be represented as an e-service denoted in quadrant IV in Figure 1 and characterized as follows:

- Non-specific partner results in no ED
- PR > threshold (δ_{vi})
- UR is equal to the sum of PR

4.2.2. E-industrial design

Almost all existing mobile phones were designed by several representative mobile phone manufacture firms. Their mutual adaptability between the customers and the providers is virtually inconsistent. Thus, a way to co-produce the design of mobile phone is increasingly important. E-industrial design is able to meet the goal and the value co-creation of the mutualism underlying one-sided high adaptability. The service delivery system constructed by the four modules including "ideation," "competition," "mutation," and "monitoring" to implement the ideation design management and process for mobile phone design (Figure 4). The PR and UR must meet the goal of the specific thresholds, which comply with the criteria of quadrant V in Figure 1 as following:

- ED > threshold (α_v)

- PR > threshold (β_v)
- UR > threshold (δ_v)
- UR is equal to sum of PR and ED

4.2.3 E-interior design

Almost all interior designs require continuously modify the coordinate, however, the design process deems that an evolve process through the interior designer and customer exchange ideas. The example of e-interior design embodies the two-sided high adaptability to fulfill value co-creation of mutualism. This service delivery system constructed of four service components including "design problem specification", "design recommendation," and "cooperative interactive CGA" as well as "evaluation" (Figure 4). The mutualism's e-services through the cooperation of service participants need to examine the criteria of ED, UR, and PR, which the service performance comply with the criteria of quadrant VI in Figure 1 as following:

- ED > threshold (α_{iv})
- PR > threshold (β_{iv})
- UR is equal to sum of PR and ED

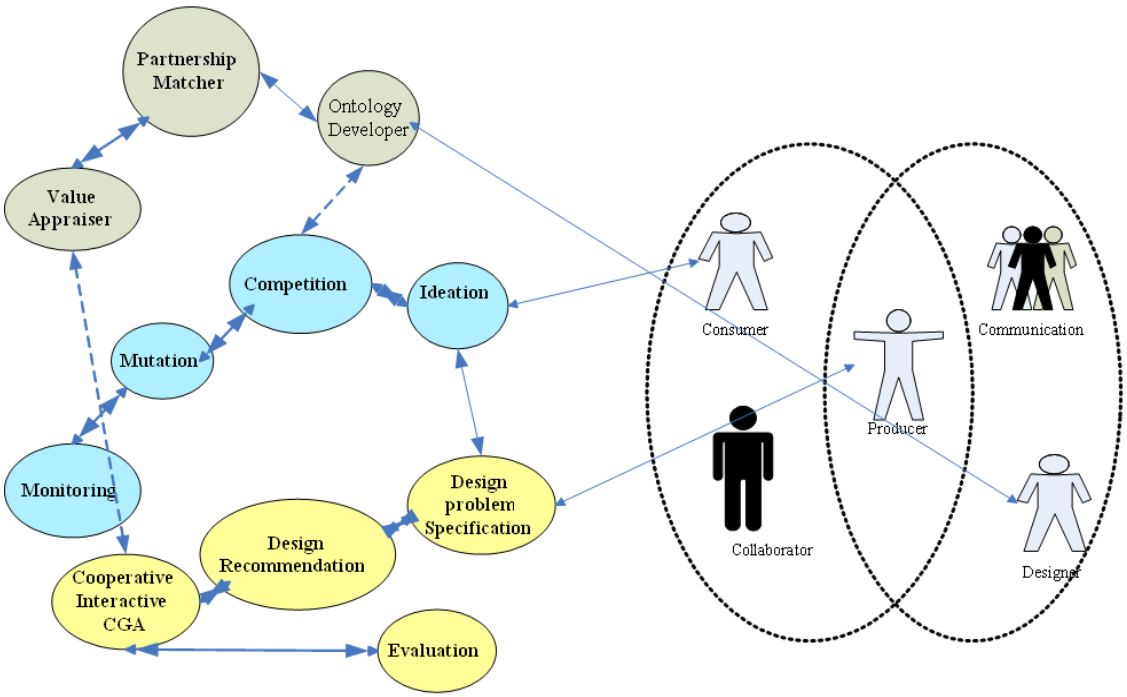

Figure 4 A Platform for the Three Service Systems

5. Managerial implication and discussion

This study has yielded finding that have both managerial insight on service delivery innovation. Along with the rise of service disciplines, there has been a parallel evolution of services research. With the emerging services science, management and engineering, advancement in service development are listed below:

- Service innovation (acquiring knowledge from outside sources, forming the collaboration and depending on highly skilled and educated employees. Given the importance of human factors, entrepreneurship is a driver.)
- Goods to services transformation (The new services refer to actual revenue-generating offerings.)
- Service and technology (Technology has become prominent in the firm-customer interface through self-service technologies.)

For the challenges of service economy, the dominance of services into the future and the strong push for continued innovation is driving a strong demand for "service innovation." The emerging information technologies allow the customers and the providers to access such systematic service innovation to create future value of service. A new frame of reference for service delivery design, the framework in this study presents a novel way to exchange service/benefit as a (semi-)automated value co-creation between consumers and providers. In terms of innovated service systems, they encompass the both natural and goal-dependent phenomena, represented respectively by concepts of symbiosis and service delivery design.

In order to create the competition of service sector, the CEO, managers, or service provider take into account how a service system can meet the goal of value co-creation with customer, not just only focus on the traditional concerns on service/products such as minimum cost. Moreover, the service infrastructures might comply with the service delivery design framework to model and develop. Especially, the interactions between providers and consumers result in the collaborative value through the service process of value co-creation.

Some marketplace begins to resemble a dialog locus organized around customers and their co-creation counterparts rather than around the passive demand for the providers. These new proposition and implications indicated that new business capabilities. Obviously, managers need a radically different approach for reigniting the growth and innovation capabilities of their enterprises. A new frontier of the study of service innovation provides a new opportunity in service economy. This desire to be successful will require restructuring and creating value in a fundamentally different way which was previously

carried out. In this emergent experience economy, research is required on further educating current and potential consumers as to what the service would be like. The service delivery design framework set forth a roadmap that recognizes the traditional service can be obsolete and that customers can engage in value co-creation and migrate into new systematic service delivery innovation. Various types of co-creation, distinguished by different levels of value proposition, can be illustrated as shown in Figure 5. This taxonomy unfolds the emerging opportunity space for service delivery design and development.

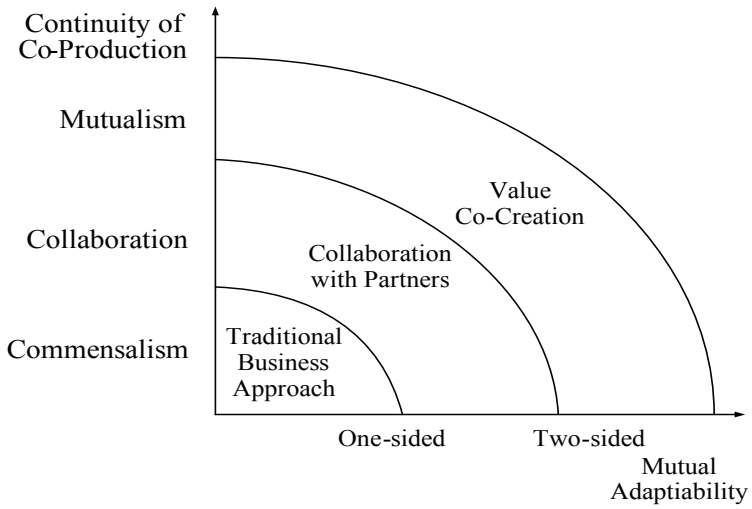

Figure 5 The Opportunity Space of Value Co-creation

New business models of service industry addressed by this study, however, the fundamental value proposition derived from the new thought such as the opportunity space of value co-creation in Figure 5.

6. Conclusion

In this paper we have presented an intelligent design framework of service systems fulfilling systematic value co-creation for service delivery underlying the ecological perspective. This research addressed an intelligent service delivery design using design science. According to the proposed framework, the service systems can be implemented by simulation to demonstrate this intelligent service delivery design. In this framework of this study, the two dimensions -- continuity of co-production and mutual adaptability -- aim to determine the diverse characteristics of service/benefit exchange and the partnership building. The framework for service delivery classification also proposes a blue print to indicate how to construct the innovated (semi-)automated value co-creation e-service. In

other words, the framework facilitates to identify a variety of intelligent service delivery designs.

As a result of the proposition of value co-creation and service delivery innovation, this study makes a great impacts on IT and business strategy. Especially, the framework is critical to facilitate to partnership building between the service provider and the customer through emerging technologies (e.g., adaptive technologies, Java, or Ajax) and system architecture (e.g., SOA). Given the value of business through the delivery of IT is the core mission of IT organizations (Hirschheim and Todd 2006). Based on the emerging IT, a service provider will be changed into a business partner. Developing partnerships might be a feasible strategy of engineering design for an innovated e-service process. With the business strategy of partnership, the changed role of IT will then transform e-service in order to enhance business value. As both suppliers-customers and technologies advance as the aforementioned, IT will subsequently shape the business mechanisms under the new vision of experience economy, An invented service systems could lead to a variety of intelligent service delivery design components for fulfilling service innovation (Figure 4).

Nevertheless, there exist certain limitations in this study. Based on the scientific model of ecological symbiosis, the classification devised by exerting two differential dimensions, continuity of value co-creation and degree of mutual adaptability, identifies diverse types of service/benefit exchange and the partnership. The two differential dimensions could be validated using the other empirical research methods in line with the nature of service exchange systems (i.e., dealing with individual relationships in human society).

The future research includes the implementation of the e-service engine based on the awareness of ecological symbiosis, which the engine will also encompass a few autonomous cognitive learning components, guaranteeing effective accomplishment of the goal as performance criteria (PR, UR and ED). Furthermore, the further service performance indicators exerted to evaluate these criteria of user experience in a service delivery process can be worthy of further investigation, regardless of domain dependence or domain independence.

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MIS Review Vol. 15, No. 2, March (2010), pp. 75-90

Non Homogenous Poisson Process Model for Optimal Software Testing Using Fault Tolerance

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ABSTRACT: *In software industry, it is important to prioritize the different modules of a software so that important modules are tested ahead of the lesser important ones. This approach is desirable because it is not possible to test each module regressively due to time and cost constraints. This paper proposes a way to prioritize several modules of a software product and calculates optimal time and cost for testing based on non homogenous poisson process. Sometimes it is more profitable for an organization to release software, even if it is not completely tested because of limited time and resources. This paper also tries to figure out whether the software could be released or not, after testing within a given time and cost.*

KEYWORDS: *Non Homogenous Poisson Process, Optimal Test Policy, Software Life Cycle Length, Testing Time, Module Test Prioritization, Fault Tolerance.*

1. Introduction

The essence of software testing is to find out any faults that might exist before releasing the product in the market. For this purpose, software product is tested carefully. The very primitive method of testing software is regression testing [15]. It is the process of testing software to make sure that old program still works with the new changes. Regression testing is any type of software testing which seeks to uncover software regressions. Such regressions occur whenever software functionality that was previously working correctly, stops working as intended. Typically regressions occur as an unintended consequence of program changes. Common methods of regression testing include re-running previously run tests and checking whether previously fixed faults have re-emerged [15]. But it is not feasible to perform regression testing on the software always, as it can be very expensive. In fact a large portion of the software maintenance budget can be consumed by regression testing [1]. That's why, a tester should find out what are the modules with greater importance so that they can be tested first and given more effort. It is impractical to test the software unless all the bugs are removed. The tester should also be aware of the optimal testing time and cost required to test the modules. When it is not possible to remove all the bugs with limited resources, then we have to accept limited faults in the software. For this reason, this paper attempts to provide an optimal boundary values for time and cost considering the actual percentage of

faults obtained in testing. A project manager should know to where it should stop testing and go for release or rejection.

A lot of work has been done in the area of optimal software time calculation by McDaid and Wilson who gave three plans to settle on the optimal time [2]. Musa and Ackerman used the concept of reliability to make the decision [3]. Ehrlich, Prasanna, Stampfel and Wu tried to find out the cost of a stop test decision [4]. But one of the most suitable models for determining optimal cost and time is proposed by Goel and Okumoto [7]. They have suggested for a non homogenous poisson process based model to determine the optimal cost and time for software [5] [6]. Praveen et al. have proposed a cumulative priority based elucidation to find out optimal software testing period [8].

Till now, the focus has been on the testing time and cost only. Previous works assume that there are errors in the software if the actual testing time is greater than the estimated time. But this assumption is incorrect when actual testing time is higher due to bad testing practices or some other reasons but not due to faults. So we can say, large number of errors means more testing time but more testing time does not mean large number of errors. This paper is also considering faults along with time and cost. The aim of this paper is to classify different modules into 5 precedence categories and to find out whether the software is ready to be released in the market after testing it for the given time within specified cost.

The next section briefly explains the background and the related work. Section 3 provides the module prioritization schema based on various factors and our approach to test the software to determine if it is tested enough. Section 4 brings an example where this approach is applied. Last section attempts to draw a conclusion.

2. Background and related work

2.1 Non homogeneous poisson process

A Poisson process is one of the most significant random processes in the probability theory. It is widely used to model random points in time and space. The examples include the times of radioactive emissions, the arrival times of customers at a service center and the positions of flaws in a piece of material. Several important probability distributions arise naturally from the Poisson process. The Poisson process is a collection of random variables where N(t) is the number of events that occurred up to time t (starting from time 0) [8]. The number of events between time a and time b is given as $N(b) - N(a)$ and has a Poisson distribution. A Non-Homogeneous process is dependent on rate parameter $\lambda(t)$ where the rate parameter of the process is a function of time e.g. the arrival rate of vehicles in

a traffic light signal. Here, we need to understand that software bugs also follow the non homogenous poisson process as the arrival of bugs in software development life cycle is random. In the following section, we can see how Goel and Okumoto used non homogenous poisson process to estimate total cost and time.

2.2 Related work by Goel and Okumoto [5][6][7]

Faults present in the system causes software failure at random times. Let N(t) (where t > 0) be the cumulative number of failures at time t (can be either CPU time or calendar time). According to Goel and Okumoto, software failure process m(t) i.e. expected number of faults detected by time t can be shown as (1):

$$m(t) = a(1-e^{-bt}) \quad (1)$$

Here, $m(\infty) = a$ where "a" represents the expected number of software failures to be eventually encountered and "b" is the detection rate for an individual fault.

According to Goel and Okumoto operational performance of a system largely depends upon testing time. Longer testing phase leads to enhanced performance. Also, cost of fixing a fault during operation is generally much more than during testing. However, the time spent in testing delays the product release, which leads to additional costs. The objective is to determine optimal release time to minimize cost by reducing testing time. Goel and Okumoto have designed the parameters c1, c2, c3, t and T which are as follows:

- c1 = cost of fixing a fault during testing
- c2 = cost of fixing a fault during operation (c2>c1)
- c3 = cost of testing per unit time
- t = software life cycle length
- T = software release time (same as testing time)

Since m(t) represents the expected number of faults during (0,t) the expected costs of fixing faults during the testing and operational phases are c1m(T) and c2(m(t)-m(T)) respectively. Further, the testing cost during a time period T is c3(T). If there is a cost associated with delay in meeting a delivery plan, such a cost could be included in c3. Combining the above costs, the total expected cost is given by (2).

$$C(T) = c1m(T) + c2\,(m(t) - m(T)) + c3(T) \quad (2)$$

This policy minimizes the average cost and depends on the ratio of a*b and Cr = c3 / (c2-c1). (3)

Two cases arise, a*b > Cr and a*b <= Cr

(i) If a*b > Cr, the optimal policy is to take

$T^* = \min (T_0, t)$ (4)

Where $T_0 = 1/b \ln(a*b / Cr)$

(ii) If $a*b <= Cr$, then $T = 0$.

If the cost of testing or the cost of delay in release is very high, this work tend to "No Testing" at all i.e. $T^* = 0$. On the other hand, if the cost of fixing a fault after release is very high as compared to the usefulness of the system, one would prefer not using the system i.e. $T^* = t$.

2.3 Related work by Praveen et al. [8][12][13]

Praveen et al proposes prioritizing the software modules into five categories namely very high, high, medium, low and very low. These categories decide the rank order of the modules to be tested in the descending order i.e. very high category modules will be tested before high and so on. Then it calculates optimal cost and time from the Goel and Okumoto work. To find out maximum allowable cost and time, stringency concept is used here. Stringency is the maximum allowable deviation from the optimum which is decided by the organization.

They advise to start testing the software to calculate the actual time and actual cost for each priority category. The deviation from optimal testing time and optimal cost can be calculated from (5) and (6). [8]

$\alpha = (Ta - T^*)/T^*$ (5)

Where α = deviation from optimal time

Ta = actual testing time

T^* = optimal testing time calculated from (4)

And $\beta = (Ca - Co)/Co$ (6)

Where β = deviation from optimal cost

Ca = actual testing cost

Co = optimal testing cost calculated from (2)

Limiting factor δ is given by (7)

$\delta = \alpha + \beta$ (7)

Afterwards it cumulatively calculates the limiting factor δ to determine whether further software testing is required.

3. Proposed approach and work

3.1 Module test prioritization schema

It is crucial to introduce a schema which ensures that the component prioritization is uniform and effective [13]. When all the modules are complete, there is a need to prioritize them for testing. Sometimes we don't have enough resources to test all the modules exhaustively. In that case we prioritize them so that modules with high priority can be tested earlier than the low priority modules. We have used the following parameters for module prioritization:

Person hour -- This is the amount of work carried out by an employee. Organization can keep track of total person hours for a module. Module priority will increase as person hours increases.

Decision density -- It can be calculated by dividing total Cyclomatic Complexity (CC) by logical lines of code [9]. Logical line of code is actual source code excluding empty lines and comment lines. Total Cyclomatic Complexity (TCC) for a module is computed by (8):

$$TCC = Sum(CC) - Count(CC) + 1 \quad (8)$$

In other words, CC is summation of all procedures. Count (CC) equals the number of procedures. The importance of TCC can be seen from this example. Suppose, there are 4 'if' decisions in a procedure, so its CC will be 5 (number of decisions +1) and its TCC from eq. (8), will be 5 (as 5 -1 +1). Now, say this procedure is split into 2 different procedures having 2 'if' conditions each i.e. a CC of 3 each. In this case also the TCC comes out to be 5 (as 6 -2 +1). So, the TCC is unaffected for the same piece of code regardless of the code split.

Weight priority -- This includes ranking given by developers, managers and customer based on the requirements and the ranking based on the risk factors. [10] Ranks are given within the range 1 to 10 for both the categories i.e. requirements and risks. There are weight factors associated with both of them in such a way that sum of these weights is 1. For example the weight factor for requirement is 0.6 and risk is 0.4. Now, say a module has requirements rank as 7 and risk rank as 8, then its total rank would be 0.6(7) + 0.4(8) = 7.4. The higher this rank is, the higher the importance would be given to the module.

Code reusability -- If an earlier source code is used in the current work with little or no modifications then we call it code reusability. This lessens the requirements of testing the code again as it has already been tested earlier.

Coupling -- It is the measure of connectedness of one module to other [11]. It is given as (9):

$$C = 1 - 1 / (d_i + 2 \cdot c_i + d_o + 2 \cdot c_o + g_d + 2 \cdot g_c + w + r) \quad (9)$$

Where C = Coupling

d_i = number of input data parameters

c_i = number of input control parameters

d_o = number of output data parameters

c_o = number of output control parameters

g_d = number of global variables used as data

g_c = number of global variables used as control

w = number of modules called (fan-out)

r = number of modules calling the module under consideration (fan-in)

Our suggested formula for calculating Module Priority is given in (10) below.

$$MP = w1 * rel.PH + w2 * rel.DD + w3 * rel.WT - w4 * rel.\%CR + w5 * rel.MC + 1 \quad (10)$$

Where MP = module priority

rel. PH = relative person hour

rel. DD = relative decision density

rel. WT = relative weight priority

rel. CR = relative code reusability

rel. MC = relative module coupling

and w1 to w5 are weight factors which fall within 0 to 1 (excluding 0).

We have taken the relative value of all parameters i.e. individual value divided by the maximum parametric value. For example, if we obtained person -- hour values as 5, 7.4, 10 and 8 for different modules. We divide all the values by the maximum value i.e. 10 in this case. Thus our relative values will be 5 / 10 = 0.5, 7.4 / 10 = 0.74, 1.0 and 8 / 10 = 0.8 respectively. The advantage of using relative parameters is that it will fix the value of a particular parameter from 0 to 1. Thus no individual parameter will enjoy superiority over other.

We have added or subtracted these parameters and not multiplied or divided them because all the parameters are within the range 0 to 1. If we multiply them we will get

very small values. For example, a multiplication of 0.9 and 0.9 will lead to only 0.81 which is even lesser than both the values. We have to add 1 to the final value obtained so that MP value falls within the range of 0 to 5. If we don't add 1 to this value then MP value would vary from -1 to 4.

After calculating the MP values for all the modules, we partition them into 5 categories, namely Very High, High, Medium, Low and Very Low. This partition is in the descending order of the calculated MP values. To find out category ranges, we divide the difference between maximum and minimum MP values obtained, by the number of categories i.e. 5. Suppose that the maximum MP value is 4.50 and minimum MP is 2.00, the category range will be (4.50-2.00) / 5 = 0.5. Therefore category ranges are Highest 4.00 ≧ to ≦ 4.50, High 3.50 ≧ to < 4.00, Medium 3.00 ≧ to < 3.50, Low 2.50 ≧ to < 3.00 and Very low 2.00 ≧ to < 2.50.

In order to make tie breaks among the modules having same MP values, organization can decide the precedence list of the individual parameters. For example, it can fix decision density as the most important parameter and see if the modules with same MP values differ in this factor. If the values are same for this factor too then it can still go further into other factors till there is a tie break. If all the parametric values are found same then these modules should be kept in the same category.

If some modules cannot be tested without testing a particular module say M, then M should be given Very High priority irrespective of its MP value.

3.2 Proposed approach for testing

After prioritizing the modules in five categories, this paper attempts to find out maximum allowable cost and time for the testing. Since weight of cost and time can't be same [12]. We have used different stringency values for both of them. The deviation value varies for different organizations. A sample of stringency values is given in Table 1:

Table 1 Sample Stringency Values for Different Module Categories

Module Category	Percentage Stringency for Time	Percentage Stringency for Cost
Very High	25%	22%
High	20%	18%
Medium	15%	12%
Low	10%	7%
Very Low	4%	3%

Let T, C be the total time and cost available to release the software. Our aim is to the test all the modules within T and C. But if we are not able to do this then at least Very High, High and Medium ranged modules should be tested. We set the fault tolerance = 0 for the first time testing of all the modules of a particular category (e.g. Very High) and find out actual time and cost for testing.

Then we start testing and note down the actual time, cost and percentage of faults obtained for each category. Note that these values are obtained after complete testing of entire individual category. Afterward we find out the deviation from optimal testing time and optimal cost from (5) and (6).

Since, time and cost might have different weights depending upon organizational needs; we modify the formula for calculating δ. The new calculations for determining δ are given by (11):

$$\delta = m\alpha + n\beta \qquad (11)$$

Where m and n are constants which are determined by organization in such a manner that there sum turns out to be 1. These constants are useful in giving different weights to cost and time. Note that we are using (11) instead of (7) for calculating limiting factor.

Table 1 is used to compute the maximum value of δ for a given category. For example, with the sample stringency values given in the Table 1, δ_{max} for Very High category will be m (0.25) + n (0.22). If the values of m and n are 0.6 and 0.4 respectively then δ_{max} for Very High category is 0.6 (0.25) + 0.4 (0.22) = 0.24. Thus we can calculate δ_{max} for all the categories. The summary calculation is given in Table 2 (with m = 0.6 and n = 0.4).

Table 2 Sample δ_{max} for Different Module Categories

Module Category	δ_{max}
Very High	0.24
High	0.19
Medium	0.14
Low	0.09
Very Low	0.04

If the δ values obtained fall under the δ_{max} limits, we understand that this category had faults within the estimated fault limit so we move further to test lesser priority

modules. But, if the δ values exceed the estimated boundary, we calculate the faults obtained in the testing to compare it with fault tolerance. Now there can be 2 cases:

Case I. actual faults ≦ fault tolerance

In this situation, we suggest to proceed to the lesser priority components. If the faults are within tolerance range, then the remaining faults can be corrected at the maintenance time. Sometimes it may also happen that there are no faults in the tested category but still the observed testing time is higher. This is because of bad testing policy, inexperience of tester or some other environmental factor.

Case II. actual faults > fault tolerance

Here, we have to debug the modules based on the faults detected till either the observed faults are within tolerance or the resources are over. After testing each time, we increase the fault tolerance a little bit. It prevents us from getting stuck in an infinite loop of testing the same category again and again. We follow this approach because we want to test maximum number of modules within limited software release time. However our aim is to debug severe bugs residing in the software.

Initially we assume zero fault tolerance for first iteration. Then we calculate new fault tolerance for each iteration, as given in (12):

$$\text{new fault tolerance} = \text{Min}(\text{max\_tolerance}, \%\ \text{faults obtained in last iteration} - \text{min\_improvement}) \quad (12)$$

Where max_tolerance is maximum fault tolerance variable whose value increases by 2% and min_improvement is minimum fault improvement variable whose value increases linearly after each iteration. The maximum value of max_tolerance is 10%. After each iteration, we increase the value of max_tolerance because our resources are become crucial. On the other hand, we increase min_improvement because it ensures less number of faults than the previous iteration. The value of variables varies from organization to organization depending upon their needs.

For example, if an organization wants to permit less fault tolerance than the value of max_tolerance has to be less and min_improvement be higher.

For example, if there are 8% actual faults in a category, max_tolerance = 4% and min_improvement = 1% then new fault tolerance will be Min (4, 8 -1) = 4.

We repeatedly test a particular category and calculate new time and cost until the errors come in the fault tolerance limit, each time exceeding the fault tolerance. If the number of faults obtained in many consecutive iterations are same i.e. we do not get any further improvement even after much iteration, than management can decide to transfer this module to some other tester. At the end of T and C, we should be able to test Very

High, High and Moderate modules. If we are stuck in a particular category for a very large time and not able to finish these 3 categories then we need to report the managers that the software is error-prone and it is entirely their risk to launch the software in market.

It should be noted that even if we are not able to test Low and Very Low categories we prefer to launch the software.

The summary of the above suggested strategy is shown in the table 3.

Table 3 Summary of Suggested Actions Based on Fault Tolerance

$\delta <= \delta_{max}$	Actual fault <= Fault Tolerance	Suggested Action
Yes	No consideration	Move to lesser priority modules
No	Yes	Move to lesser priority modules
No	No	Increase fault tolerance, debug and test again to calculate new cost and time

Further work can be done in selecting the sample of test cases for low level categories when we don't have enough time and cost left to test these categories completely.

4. Case study

We applied the concept to a trie based dictionary software. A trie is an ordered tree data structure [16] used to store associative array. The position of the node in the tree showed only what key it was associated with [14]. In order to build a dictionary, each node contained a single character; words can be retrieved in pre-order traversal of the trie. It takes an input text file containing words and corresponding meanings and stores them in a trie. After this it performed various dictionary operations. The major functionalities of this software product could be viewed as:

- Main menu driven option module for user input
- Reading a file to store data
- Finding a word
- Inserting a new word to dictionary
- Adding meaning to the word
- Editing the word meaning

- Storing back the dictionary to a new file

We identified seven major modules namely main module, read file, find word, insert word, add meaning, edit meaning and print. The weight factor for these modules could be calculated as given in Table 4, where relative weight is total/max value in total column:

Table 4 Calaulating Weight Factor for Dictionary Modules

Module Name	Requirement Factor (0.6) (0.6 is weighted factor)	Risk Factor (0.4) (0.4 is weighted factor)	Total	Relative Weight
Main	7	7	7	0.78
Read File	7	8	7.4	0.82
Find Word	9	7	8.2	0.91
Insert Word	9	9	9	1
Add Meaning	7	8	7.4	0.82
Edit Meaning	6	7	6.4	0.71
Print	9	6	7.8	0.87

The, main module had requirements rank as 7 and risk rank as 7, so its total rank was 0.6(7) + 0.4(7) = 7. This ranking i.e. 7 for requirement and 7 for risk factor was given by developers, managers and customers based on their experience [10]. To calculate relative weight, we divide total by max (total). In this case max (total) was 9 that cames from Insert Word module. So, the relative weight for Main module was 7 / 9 = 0.78. Similarly, other modules' relative weight could be calculated.

Then we found out coupling among these modules, calculations for coupling are shown in the Table 5. The procedure to find out relative coupling in the Table 5 is coupling/max (coupling).

Table 5 Calaulating Coupling for Dictionary Modules

Module	Module Coupling = 1 /(input, output, global, fan out, fan in)	Coupling =1- 1/M	Relative Coupling
Main	1 / 0+1+4+6+0	0.91	1
Read File	1 / 2+0+1+1+1	0.80	0.88
Find Word	1 / 2+1+0+0+1	0.75	0.83

Table 5 Calaulating Coupling for Dictionary Modules (Continued)

Module	Module Coupling = 1 /(input, output, global, fan out, fan in)	Coupling =1- 1/M	Relative Coupling
Insert Word	1 / 4+2+0+2+2	0.90	0.99
Add Meaning	1 / 3+1+1+0+2	0.86	0.94
Edit Meaning	1 / 3+1+1+0+1	0.83	0.91
Print	1 / 3+0+1+1+1	0.83	0.91

Similarly we computed rest of the parameters. Final values for the modules are given in the Table 6.

Table 6 Final Modules Priority Values

Module	A	B	C	D	E	F	G	MP	Category
Main	0.67	36	183	0.74	0.78	0	1	4.19	High
Read File	0.17	4	31	0.48	0.82	0	0.88	3.35	Low
Find Word	0.5	5	23	0.81	0.91	0	0.83	4.05	High
Insert Word	1	15	92	0.59	1	0	0.99	4.58	Highest
Add Meaning	0.17	4	26	0.56	0.82	0	0.94	3.49	Medium
Edit Meaning	0.17	4	37	0.41	0.71	0	0.91	3.20	Very Low
Print	0.83	7	26	1	0.87	0	0.91	4.61	Highest

Where a = relative person hour

b = total cyclomatic complexity

c = logical lines of code

d = relative decision density

e = relative weight factor

f = relative code reusability

g = relative coupling

MP = module priority which is calculated by (10)

Here, we saw that the maximum MP value was 4.61 and minimum MP was 3.20. So, the category range was (4.61-3.20) / 5 = 0.28. Hence category range Highest was in between 4.33 ≧ to ≦ 4.61, High is in between 4.05 ≧ to < 4.33 and so on. In our case study, though last 3 modules fell in the Medium category yet different categories were assigned to them i.e. 3.49 in Medium, 3.35 in Low and 3.20 in Very Low, just for demonstration purpose, as our project size was not large enough. But in large projects, each category will have some modules in it.

After this we calculated δ_{max} values for these modules from (11) and using stringency values from Table 1. We also found out optimal time and cost from (2) and (3) respectively. Optimal values are given in Table 7. Please note that for different values of c1, c2, c3, t and T these values are different.

Table 7 Optimal Cost and Time Values

Category	Optimal time	Optimal cost	Max time	Max cost
Highest	5.00	10.50	6.25	12.81
High	4.50	8.80	5.40	10.38
Medium	3.00	6.90	3.45	7.73
Low	3.00	5.80	3.30	6.21
Very Low	2.19	5.20	2.28	5.36

Then, assuming that we had total 18 time units and 36 cost units to test the software (you can calculate from cocomo model [11] also). We will calculate the highest priority category modules first. After testing this category we obtained the actual time, cost and percentage fault values as 5.5, 11 and 2% respectively. Since here $\delta < \delta max$ so we moved to the next priority modules i.e. high priority modules in spite of the faults exceeding the tolerance limit.

Now we received time, cost and percentage fault values as 6, 10 and 3% respectively. Here $\delta = (6 – 4.5) / 4.5 * 0.6 + (10 – 8.8) / 8.8 * 0.4 = 0.25$ from (5), (6) and (11). Since $\delta > \delta_{max}$ as the δ_{max} value for high priority modules was 0.19 from Table 2, we considered percentage of faults obtained. Since this percentage fault was outside the fault tolerance (for first iteration it is 0), we had to test this category again with an increased fault tolerance of 2% (if max_tolerance = 2% and min_improvement = 1% then from (12) new tolerance = min (2, 3-1)). Next time, we got time, cost and percentage faults as 4.7, 6.7 and 1% respectively. Again here $\delta < \delta max$ so we moved to lesser priority i.e. medium priority modules.

This time we got time, cost and percentage faults as 3, 8 and 0% respectively. Since $\delta > \delta max$ in this case, we had to look into percentage faults. Since these faults were within tolerance, we did not look into this priority again.

By that time, our resources (time and cost) were over therefore we checked which priority modules were tested enough. Since we could test highest, high and medium priorities, the software was ready to be launched.

5. Conclusion

This paper has illustrated how we can prioritize the software modules in order to test the important modules primarily. Non homogenous poisson processed model helps us to calculate the optimal testing time and cost. After allowing a little deviation from these values and accepting low risk faults in the system, we can test the software effectively even if we have limited resources available with us. Fault tolerance concept assists us to test the software in a given time and cost. At the end of the resources, we can also find out if we have tested enough or there is a further need of testing the important modules. This facilitates us to make a decision whether the software product is ready to be released in the market or not. The approach described in this paper is more suitable for the situations where there are fixed values for testing time and cost. Further research can be carried out to find out more accurate ways of assigning categories to the modules based on clustering or graph theory. Yet another open issue is to determine the appropriate values for min_improvement and max_tolerance variables.

Acknowledgement

We thank to Dr. Sanjiv K. Choudhary, BITS Pilani for many insightful discussions for proof reading of this article.

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