Constructing Collaborative Service Systems: A Mutualism-Based NSD Method

Wei-Feng Tung and Soe-Tsyr Yuan

***Abstract*—This paper describes an analytic and synthetic new service development (NSD) method for devising collaborative service systems (CSSs). The predominant NSD method is a process-based one that belongs to the well-established service blueprints approach in order to create flexible flowchart-like models of customer–provider interaction flows. In contrast to the static service blueprints approach, the proposed NSD method belonging to CSSs includes the service operation management design adopting the proposed mutualism-based NSD method (MBNSD). This paper also presents a novel conceptual metaphor between ecological mutualism for species and value coproduction for service providers and customers. The CSSs designed by MBNSD enable the automated value coproduction (mutualism) for service participants (species). Constructing CSS initially involves identifying value coproduction-based service concepts (mutualism-what), modeling service encounters and service exchanges adopting evolutionary algorithms and optimization methods (mutualism-how), as well as estimating their collaborative service-quality (CSQ) (fitness) to determine whether the service participants achieve mutualism and adaptability (evolution). MBNSD consists of three phases: identifying and determining CSS classifications, designing and modeling CSS applications, and estimating and managing CSS CSQ. Moreover, three cases are described that involve CSS applications, i.e., iMusicCreation, iInteriorDesign, and iMobileDesign, that are designed based on MBNSD. Importantly, this systematic procedure of automating service value coproduction based on MBNSD significantly contributes to NSD applications and research.**

***Index Terms*—Collaborative service quality (CSQ), collaborative service system (CSS), mutualism, new service design, new service development (NSD), service innovation, service quality, value coproduction.**

I. Introduction

HAVING received considerable emphasis in many service industries, new service development (NSD) focuses on identifying consumer choices and preferences for the design and formulation of operational strategies in NSD [12]. Specifically, NSD stresses design and configure service concept elements. The predominant NSD method is a process-based service blueprints approach [3]. Service blueprints can be easily created to understand flowchart-like models of customer–provider interaction flows. A notable example is how a customer experiences hotel service, from checkin to checkout. However, systemic thinking of services views a service as consisting of a set of elements that interact with each other to create a certain behavior and achieve goals at the experiences of the whole service process [28]. Additionally, as a dynamic value coproduction configuration of individuals, technologies, other internal and external service systems, as well as shared information [30], a service system addresses the open and dynamic nature of the value coproduction in services. Restated, by extending the conventional static service blueprint approach, the novel NSD method is highly promising for research and service innovation.

This study presents a mutualism-based NSD method (MBNSD) to construct collaborative service systems (CSSs). Modeled as species that interact and coevolve over time, CSSs adopt the analogy metaphor between ecological mutualism for species and value coproduction for service providers and customers (service participants). As the needs and capabilities of a species evolve over time, interactions between species subsequently change as well. Additionally, demand has grown rapidly for this approach in recent years, as customers and providers dynamically change the nature of their interactions. For instance, individuals, businesses, and nations strive to adapt more responsively to environmental challenges and opportunities. Technology and outsourcing can rapidly transform customer and provider interactions.

As a new NSD, MBNSD can quantify and monitor service quality of a CSS. A CSS refers to an e-service that facilitates value coproduction automation to increase service productivity and satisfaction by facilitating, assisting, or mediating the interactions among service providers and customers during service delivery process. MBNSD allows us to understand not only how to develop a CSS but how to evaluate the collaborative service quality (CSQ) of CSS as well.

MBNSD consists of the following three phases. The first phase is a CSS classification matrix that comprises the four CSS types classified based on two dimensions, i.e., the degree of value coproduction and the degree of mutual adaptability. The second phase is a system-analysis procedure that characterizes CSSs in terms of a set of salient determinants (i.e., goal, problem-solving strategies, solution requirements, theories, tacit knowledge, and design methods) and embodies the shared reality of the value coproduction process (i.e., objective, context, and content). Moreover, a system design scheme to model CSSs involves designing an e-service that can automate the cognitive process and knowledge representations (characterized by the salient element of the embodied theory in support of the value coproduction process with the ultimate

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intent of maximizing satisfaction and optimizing productivity). Moreover, a service decision can be optimized by using evolutionary algorithms, e.g., genetic algorithm (GA) and cooperative interactive coevolution GA (CICGA) [50], [52]. The third phase is a service-quality model that estimates CSQ, i.e., the quality during the service delivery process by evaluating mutualism and testing the adaptability of service providers and customers [18], [34]. Additionally, case studies are presented to demonstrate and evaluate the effectiveness of three prototypes that are IT-facilitated/mediated/assisted CSS applications: iMusicCreation, iInteriorDesign, and iMobileDesign.

The rest of this paper is organized as follows. Section II introduces the conceptual metaphor. Section III then describes the NSD and new service design, followed by a review of current NSD methods. Then, Section IV addresses the MBNSD method. Additionally Section V introduces three CSS cases to demonstrate the effectiveness of the proposed NSD method. Moreover, Section VI summarizes the managerial implications of the proposed NSD method. Conclusions are finally drawn in Section VII, along with recommendations for future research.

II. Conceptual Metaphor

Metaphor can often be viewed as an inspiration for design problems [39]. Here, mutualism of ecology is associated with the value coproduction of service systems in thinking. Based on cross-domain mapping, this study presents a mutualism-based method for CSS design. One metaphor is an analogy between ecological mutualism for species and value coproduction for service providers and customers (service participants).

According to organizational scientific perspectives [33], metaphors encourage different thinking styles, enabling social scientists and layperson to focus on, explain, and influence different aspects of complex organizational phenomena. Metaphors transfer information from a relatively familiar domain to a new and relatively unknown one [24]. An analogy "operationalizes" a metaphor or a simile by focusing on how items are related. While comparing and distinguishing between an ecosystem and a service system, this study posits a transformational view for metaphors in service science [45]. Some phenomena in ecological mutualism are analogous with value coproduction between service providers and customers on account of the mutualistic interdependence relationship [50], [51]. This study also incorporates the mutualism of metaphorical insights into scientific and quantitative research on collaborative service models and service systems. As for transformation, the earlier process of concept transformation does not need to be an isolated top-down movement. When following a downward path, knowledge of a certain phenomenon or object is accumulated and a scientific model becomes available. As this scientific model represents the starting point for an upward movement, a conceptual model of the new phenomenon or object under study can be developed.

Insight into the homomorphic model can be applied to the target domain of organizational populations, where a homomorphic model can describe organizational evolution. Theoretical assumptions of natural selection are applied to organizational

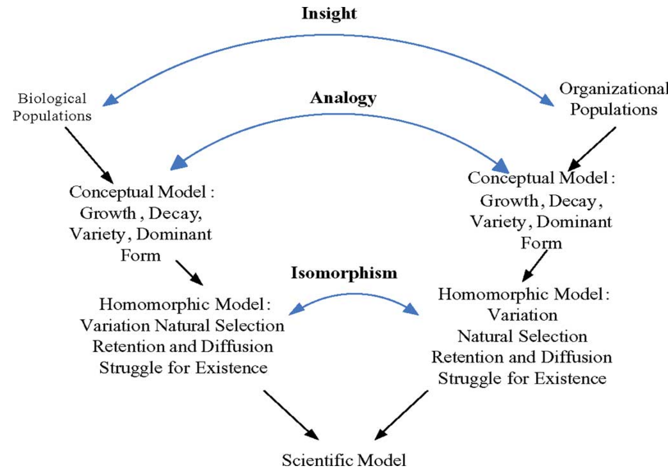

Fig. 1. Transformational reconstruction method of the population ecology perspective [33].

populations, subsequently forming the foundation for a research program. The outcome of thinking in parallel about organisms and organizations results in a scientific model of high generality that is pertinent to both organisms and organizations for a precisely defined area of activity. Therefore, the transformational view of metaphors highlights the underlying mechanisms that explain the phenomena under study. The scientific model is attributed to top-down or downward from insight, analogy, and isomorphism (see Fig. 1).

Exactly how ecological species and service participants are related is then described. The analogy of a conceptual model can be viewed as a correlation between service exchange and service delivery in a service system, and adaptability and evolutionary in an ecosystem. The outcome of a scientific model is a convergence from two conceptual models of an ecosystem and a service (see Fig. 1). Mutualism refers to the mutually beneficial interaction between individuals of two species [18]. Table I displays the formation of the analogy between mutualism in ecosystem and value coproduction in CSSs. Therefore, this study demonstrates the feasibility of using ecological mutualism theories to come up with MBNSD.

MBNSD can automatically construct a value coproduction relationship among service participants (species), the determinants of collaboration (mutualism-what), the design and development of service encounters (mutualism-how), and the evaluation of service quality (fitness of adaptation) in order to determine whether the service participants achieve evolution (fitness of evolution). Mutualism refers to whether service participants have achieved a mutualistic relationship (mutualism). Adaptability refers to the interactive fitness (IF) of service participants to determine their ability to adapt sufficiently in order to achieve value coproduction. Fig. 2 shows the analogy of a method for constructing a CSS with ecological mutualism, adaptation, and evolution. Evolution is referred to hereinafter as situations in which each species can adapt to their environment and account for a great variety within each species.

MBNSD thus offers a unique service design method that can function as a systematic and quantitative means of facilitating

TABLE I
ANALOGY BETWEEN ECOLOGICAL MUTUALISM AND VALUE COPRODUCTION

Mutualism in Ecosystem	**Value Co-Production in Collaborative Service Systems**
• Mutually beneficial interaction	• Mutually beneficial relationship
• Individuals from two species	• Service provider and customers
• Co-evolution and adaptation in the mutualism processes	• Evolution and adaptation in the value co-production process
• Species performance to evaluate mutualism	• Service performance to evaluate mutualism

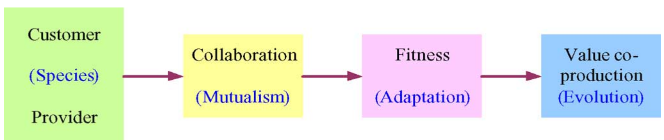

Fig. 2. Analogy between ecological mutualism and service value coproduction.

the construction and implementation of CSS underlying the mutualism concepts and theory.

III. NEW SERVICE DEVELOPMENT AND NEW SERVICE DESIGN

Service definitions and service design have often emphasized the intangible, activity-based, and participatory nature of service acts. Vargo and Lusch [53] defined services as "the application of specialized competences (knowledge and skills), through deeds, processes, and performance for the benefit of another entity or the entity itself." Bitran and Pedrosa [2] asserted that the proportions of intangibility within services are more than tangiblility (e.g., understanding customer needs, underlying reasons, and how to deliver services that pose challenges to NSD, given a service is a time-perishable, intangible experience performed for a customer acting as a coproducer [2], [41], [42].

A. Background

NSD generally includes phases, such as service concept design and development, system design, and system construction and testing before the launching of a service [9], [14], [19]. Restated, customer needs derived from investigations, e.g., depth interviews, focus groups, and observations, are initially transformed into NSD specifications, subsequently allowing new service concepts to emerge. Second, further clear and definitive specifications are necessary [44]. Third, service/e-service can be deployed based on explicit specifications of the earlier phase. Johnson *et al.* [14] indicated that service development specifies the detailed contents and configuration of a service concept and operations strategy. Service development should stress the operational basics of a new service, which includes understanding and planning the interaction of various physical, electronic, and human elements [8], [38], [52].

An alternative notion similar to NSD, commonly referred to as new service design, often refers to the "overall process of developing new service offerings" [14] and is concerned with a comprehensive set of stages from an idea to the product/service launch [46]. Edvardsson *et al.* [42] extended the scope of new service design to encompass strategy, culture, as well as service policy deployment and implementation [41], [42]. Norling *et al.* [48] defined specifying a new service concept in drawings and specifications [48]. Other efforts have adopted the term service design to cover the entire process from idea to specification [38], [47]. Gummesson [49] more narrowly defined service design as "the concretization of the service concept in drawings, and flowcharts." The service concept describes its use in enhancing a variety of service design processes, and it encompasses all goods and services sold to customers and the relative importance of each component to them [10], [26].

Many traditional service studies are regarded as belonging to management science [25], [31], especially marketing science, thus having a rather limited contextual focus owing to a lack of cross-disciplinary approaches [27], [43]. While the service sector has dominated advanced economies for many years, the demand for service innovation has grown rapidly in recent years. Service-science-related studies focus mainly on how service innovation can be systematic, quantitative, and standardized in order to increase service productivity and customer satisfaction, as well as transform most e-services toward automation of value coproduction [17], [30]. Moreover, the conventional business model for the service sector or Internet-based services can penetrate service management into systematic service innovation. Yang *et al.* [37] indicated that knowledge workers can develop products and services by applying their theoretical and analytical skills [37]. Based on their assertion that designing high quality into the service system from the outset and effectively responding to customer expectations while designing each element of the service are of priority concern, Zeithaml *et al.* [38] developed shared mental models that allow team members to share common expectations with respect to the team processes, results, and individual roles in order to develop products and services.

Additionally, according to Roth and Menor [26], the research framework of service operation management (SOM) is organized around three major interrelated and dynamic components of service delivery systems, i.e., strategic service development choices, service delivery system execution and assessment, and customer-perceived value of the total service concept [26]. Strategic service development choices include structure, infrastructure, and integration. Therefore, with an emphasis on systematic and quantitative service delivery and innovation, new service system design methods should address the three aforementioned interrelated SOM issues, as well as consider cross-disciplinary approaches. This study presents MBNSD approach to service system design targeting on CSS, which focuses mainly on analyzing and designing CSS that feature automated value coproduction and systematized service innovation with productivity and satisfaction. Notably, MBNSD is a multidisciplinary approach that draws from symbiotic mutualism, service science, and information technology [43].

B. Current NSD Methods

Current NSD methods originate mainly from industry. A notable example is NSD of the International Organization for Standardization (ISO), which requires service concepts transformation and quality control required in the manufacturing process. Customer needs should be clearly specified including the service, service delivery, and service control that focus on services and organizational perspective (e.g., policy, costs, and goals). However, Edvardsson and Olsson [7] posed several questions regarding the NSD process of ISO, in which customers are viewed as end receivers who passively receive services rather than viewed as part of the service. This is in contrast with a perspective in which customers are viewed as cocreators within the services, and the service contents can be adjusted based on such a collaboration [7]. However, current methods that originate from the industrial sector, which are aimed toward service system design as process-oriented methods, are similar to product design. Notable examples include the Fraunhofer Institute for Industrial Engineering (IAO), Germany; TRIZ-Based method for NSD, Singapore; Tekes Research Institution, Finland; Cranfield Service Management Center; U.K.; Fujitsu Laboratories, Japan; as well as the Institute for Information Industry (III) and Industrial Technology Research Institute (ITRI), Taiwan.

Fraunhofer IAO initiated research activities focusing on service engineering in 1995 [3], subsequently launching service research projects, e.g., holistic service engineering, computer-aided service engineering, and customer-oriented service development. The research institute addresses issues, such as technologies, service provisions, service developments, and service innovation, as well as related impacts and trends during an economy transformation. Fraunhofer IAO also established a ServLab to evaluate new services. The Institute for Information Industry in Taiwan combines the service engineering method of Fraunhofer IAO with experience engineering, which provides experience identification, modeling, and simulation using service experience engineering (SEE) that strives to help NSD developers to develop services that comply with customer requirements and create unintended experiences.

The theory of inventive problem-solving (TRIZ) is a problem solving method based on logic and data, (not intuition) which accelerates the ability of a project team in solving problems creatively [1], [4], [6]. TRIZ provides repeatability, predictability, and reliability due to its structural and algorithmic approach. Using TRIZ, more than 3 007 000 patents have been analyzed to identify the patterns that predict breakthrough solutions to problems. Applying TRIZ to service can be an innovative approach to NSD. Additionally, Ulrich and Ellison [35] indicated that a firm benefits from designing product-specific components when it is important, from a competitive perspective to maximize product performance with respect to holistic customer requirements, minimize the size and mass of a product, and reduce the variable costs of production [35]. They referred to this phenomenon as a design-select decision, which can consider quantitatively and qualitatively the advantages of components to design product-specific components.

Table II summarizes and contrasts the individual objectives, methods, capabilities, methodology concepts, and examples of three common NSD methodologies, i.e., SEE-based on Fraunhofer IAO's, the TRIZ-Based method, and the proposed MBNSD approach.

Most NSD methods lack systemic thinking in terms of value coproduction configuration and evolution (see Table I). Also, devising quantitative and systematic methods for innovative NSD is extremely difficult. Restated, systematic service innovations seldom incorporate a method that evaluates and manages the performance (i.e., CSQ) of service systems, necessitating the development of methods that build up current ones, e.g., Fraunhofer IAO, SEE-, and the TRIZ-based method, in which quantitative NSD methods are provided as well.

This study introduces a novel conceptual metaphor of mutualism among species into the scientific and quantitative NSD in order to construct CSSs. Notably, benefits of species in mutualism are related to the value coproduction of service participants. Additionally, the value coproduction performance can be assessed by quantifying CSQ with mutualism assessment. As monitoring is recognized capable of distinguishing an effective CSQ from poor service experiences by using a fitness OR fitness's assessment, the proposed MBNSD approach may thus overcome the problem of qualitative (CSQ in CSS).

IV. MBNSD: Mutualism-Based New Serivice Development Method for Constructing Collaborative Service Systems

This study focus on how the service sector adopts the NSD method to analyze, design, and deploy CSS applications that can automate value coproduction between service providers and customers. The section illustrates the effectiveness of a three-phase method by identifying and determining CSS classifications, designing and modeling CSS applications, as well as estimating and managing CSS (see Fig. 3).

The comprehensive NSD method addresses how to design and model the needs of systematic service innovation (see Fig. 4). The following sections describe how a service sector or system developers analyze, design, and implement a CSS, capable of increasing service productivity and satisfaction effectively. Effectiveness of the proposed method is also demonstrated through three case studies involving CSS applications, i.e., iMusicCreation, iInteriorDesign, and iMobileDesign, which are constructed by the proposed MBNSD.

A. Phase I: Identifying and Determining CSS Classifications

The MBNSD method starts with a CSS classification matrix, capable of identifying CSS type based on ecological mutualism behaviors. When developing a CSS, the service sector must determine a CSS that complies with factors, such as their real-service concept, service process, and tacit knowledge. The CSS classification matrix belongs to four types: category services, transactional marketplace, collaborative affiliate, and

TABLE II
COMPARING THESE NSD METHODS

	Fraunhofer IAO SEE	**TRIZ-based Method**	**Mutualism-baeed Method (MBNSD)**
Objective	Methods for service experience engineering	Systematic design and innovation in the service domain	Systematic CSS featuring automated value co-production using an analytical and quantitative MBNSD.
Phases of Method	1.Idea management 2.Requirements analysis 3.Service design 4.Service implementation 5. Market launch	1.Problem definition 2.Problem resolution 3.Solution evaluation 4. Problem re-definition	1. Identifying/ determining CSS classification, 2. Designing/ modeling CSS, 3.Estimating/ managing CSS
Capabilities	Model customer experience, analyze hidden service needs, and simulate customer experience	Identify, generate, and evaluate possible solutions to service problems	Systematic and quantitative service delivery and service performance of CSS.
Method Concepts	Integrate service engineering methodology with experience engineering	Integrate TRIZ problem-solving tools with its pattern knowledge base	Adopt the three-phase MBNSD method based on mutualism and co-evolutionary theory
Tools and Procedures	Methods (QFD, SADT, FMEA, service blueprinting, conjoint analysis, product modeling, process modeling, role concepts, target costing and pricing) process models (waterfall, spiral and prototyping)	Problem formulator, Tool-object-product, Function modeling, Substance-Field analysis, 40 Inventive Principles, 4 Separation Principles, 76 Standard Solutions, ARIZ	CSS classification matrix Modeling approach to designing CSS applications Integrated model of CSQ.
Examples and Applications	Yulon molife TOBE Services, Changhua Christian hospital & Q-Shop	Redesign of the sightseeing scheme in Singapore Sentosa Island, restructuring the operations at a University Canteen	iMusicCreation (Transactional marketplace CSS) iMobileDesign (Collaborative affiliate CSS) iInteriorDesign (Cooperative personalization CSS)

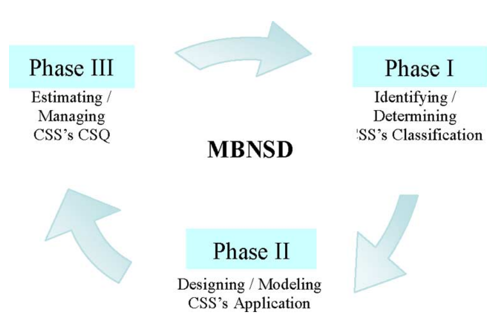

Fig. 3. Three-phase procedure of the proposed MBNSD method.

cooperative personalization service system (see Fig. 5). Restated, relationships between service participants (species) are based on the metaphorical insight of mutualism.

From ecology perspectives, mutualism is the mutually beneficial interaction between individuals of two species [18]. We believe that defining the service classification comprises the two dimensions of continuity of value coproduction and mutual adaptability, which are characterized by the benefit-exchange behavior when service participants become partners within a service. Determining which partnership is the most appropriate depends on the way to align between the provider and customer. The four categories of CSSs involved in the mutualism-based CSS classification matrix correspond to the specific characteristics related to the benefit-exchange among service participants.

In the MBNSD for CSS applications, the CSS type should be first determined and can serve as the design principle for further designing CSS applications. Restated, the matrix can also provide a reference for making definite claims regarding NSD along the classification.

Classification is grounded on the scientific metaphorical insights into mutualism relationships and defined as a 2-D classification along with value-based coproduction and degree of mutual adaptation.

1) *Degree of value coproduction:* This concept addresses high/low continuity of value coproduction identified

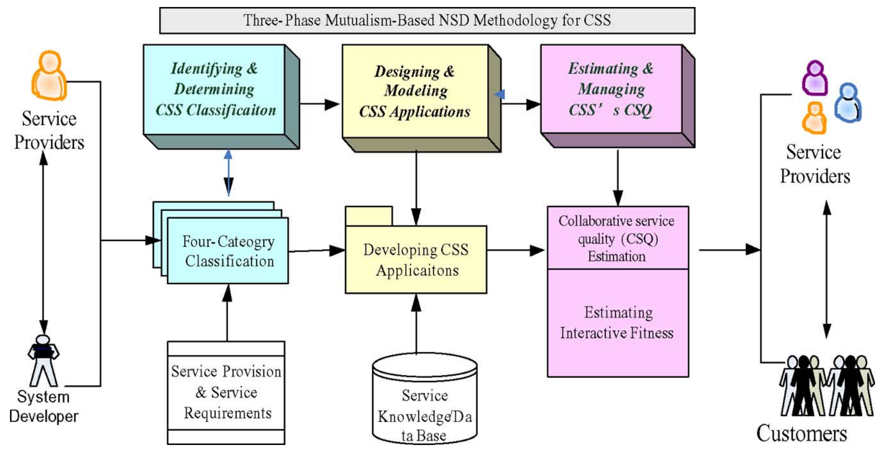

Fig. 4. Holistic procedures of the proposed MBNSD method.

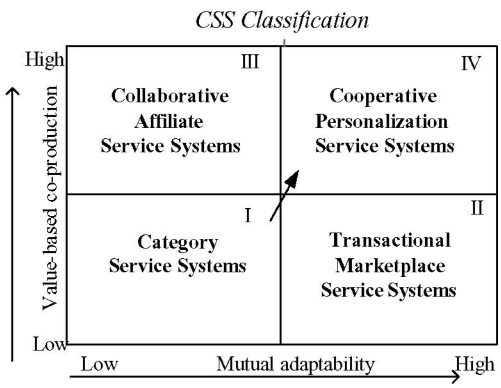

Fig. 5. CSS classification of MBNSD.

by what mutualism that the provider/customer can achieve. Two relationships of the mutualism involve the following.

a) *Mutualism:* Mutually beneficial interactions occur between providers and customers. The specific and fixed partnership between providers and consumers is necessary for delivering a service.

b) *Collaboration:* Mutually beneficial interactions occur between providers and customers. A specific partner is unnecessary, and the provider and the customer do not require a fixed relationship in order to deliver a service.

2) *Degree of mutual adaptability* This concept addresses how the provider/customer adapts to their partners when the former exchanges a service. The dimension of mutual adaptability derives from the well-known evolution underlying modern ecology that describes the adaptive change, as organisms respond to their environment, i.e., Darwin's evolution theory. Two mutual adaptability forms are as follows.

a) *One-sided adaptability:* Either providers adapt to customers, or customers adapt to providers.

b) *Two-sided adaptability:* Providers and customers adapt to each other to ensure high flexibility in changing the objectives of the partnership.

By considering the continuity of value coproduction and the degree of mutual adaptability, the classification matrix then identifies the following core types of interactions during the exchange of services/benefits (based on which semi-automatic mechanisms that their service exchanges are featured in the characteristics of each classification, as denoted by quadrants I–IV in Fig. 5):

1) Category Service Systems: Only one side, e.g., the provider, provides services to others, e.g., customers, with a low level of coproduction. Namely, one-sided adaptability occurs when a provider collaborates with unfixed customers. This situation generally represents mass e-service, e.g., a B2C service, such as e-banking and Yahoo shopping.

2) Transactional Marketplace Service Systems: Both sides, i.e., the provider and receiver, exchange benefits with the adaptabilities to satisfy a low level of coproduction in a collaborative service. This collaborative relationship with unfixed partners is analogous to nonobligatory mutualism in ecology. Unfixed partners refer to nonspecific counterparts of service participants involved in a short-term relationship, e.g., an individual using services on the Internet, such as Wikipedia and Youtube.

3) Collaborative Affiliate Service Systems: One side, i.e., the provider, with the adaptability exchanges services as a mutualistic service to satisfy the high level of coproduction. This mutualism relationship with unfixed customers is analogous to the obligatory mutualism in ecology.

4) Cooperative Personalization Service Systems: Both sides, i.e., the provider and customer, with the adaptabilities exchange benefits to satisfy a high level of coproduction. This mutualism relationship with fixed partners is analogous to the obligatory mutualism in ecology. Classification of the proposed CSSs provides four e-services in which service participants increasingly foster collaborative partnerships when service encounters have occurred during the service exchange.

B. Phase II: Designing and Modeling CSS Applications

The second phase in the method models and designs an analytical and synthetic artifact for a specific CSS. For service productivity and satisfaction, this phase provides an effective

TABLE III
BASIC ELEMENTS OF SERVICE DESIGN AND TACTICS OF MODELING CSSS

Basic Elements of Service Design	Tactic for Design and Modeling CSS
Goal	Automated value co-production and further systematic service innovatior to increase service productivity and customer satisfaction
Problem solving strategy	Facilitated/mediated/assisted collaborative service delivery process or self-service technologies
Solution requirement	Maximum satisfaction
Theories	Multidisciplinary theories or methods
Tacit knowledge	Information, knowledge, and decisions of individuals involved
Design method	Design-science (creating synthesized IT-artifact) [11,15]

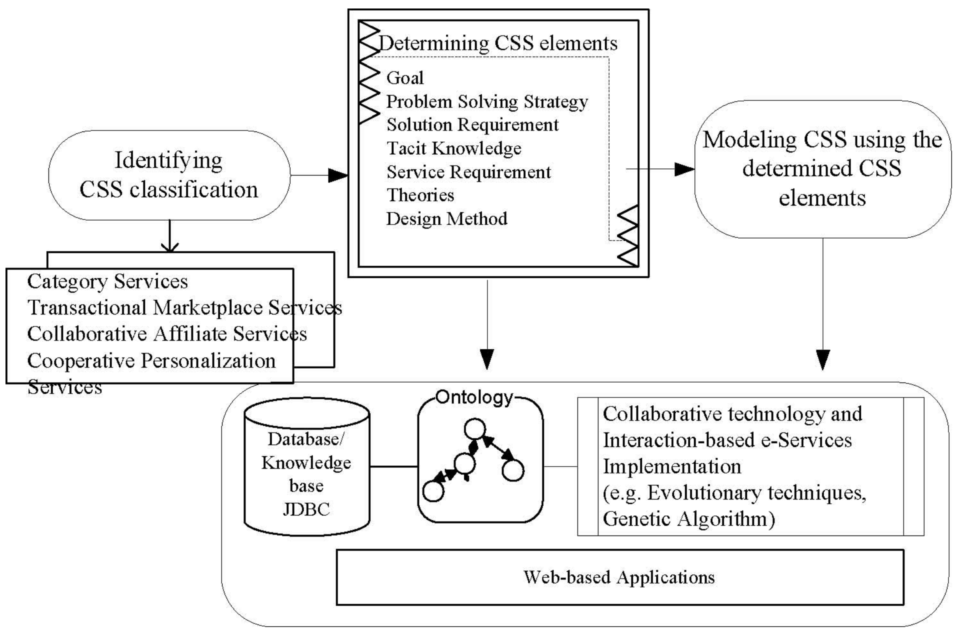

Fig. 6. Phase II: Designing and modeling CSS applications.

modeling and designing core human cognitive processes and knowledge representations.

1) Designing CSS Applications: A service system involves individuals, models, architecture, and technologies for modeling and automating the service process. Designing a CSS involves a technological framework that addresses basic attribute elements, such as CSS components for analysis-developing thinking while serving as a basis for CSS. Namely, these elements shape the interactions of all relevant factors and actors simultaneously, subsequently influencing the trajectory of the service systems. By drawing from the social technical system [16], the technological framework of a CSS includes six attribute elements that jointly specify a NSD problem toward a systematic service innovation with the advantages of service productivity and with the shared service reality of purpose (intentions of stakeholders), context (circumstances of stakeholders), and content (information and decisions rendered by stakeholders w.r.t. their purposes and contexts). Table III lists these attribute elements, which represent the determinants of collaboration (mutualism-what) according to the metaphorical insight of mutualism.

2) Modeling CSS Applications: The second phase in the method attempts to construct quantitative and systematic CSS with a high service productivity and user satisfaction, i.e., achieving NSD. Namely, the service cognitive process and knowledge representations are modeled using the evolutionary method in which a symbiosis-way collaboration is engaged to reduce communication costs and eliminate service operation costs (see Fig. 6) [50]. Restated, constructing CSS applications entails designing and developing a service value coproduction delivery process that encompasses the service encounters with the ultimate objectives of maximum satisfaction and optimal productivity, i.e., the mutualism-how based on the metaphorical insight of mutualism. Additionally, service delivery decisions within CSS applications can be optimized based on evolutionary algorithms, e.g., GA and CICGA.

In service science research, the service-dominant logic provides a framework for theorizing the foundation of service science [53]. Within this logic framework, the customer is always a cocreator of value; value creation is interactional, and value is always uniquely and phenomenologically determined by the customer [54]. However, each of the four categories of CSS classifications (as mentioned in Section IV) exhibits certain specific characteristics relative to the benefit exchange among service participants. Therefore, for a CSS application, designing and developing an automated service value coproduction service

TABLE IV
DESIGNING AND MODELING IMUSICCREATION

Basic Elements of Service Design	Tactics for Designing and Modeling CSS -- iMusicCreation
Goal	• Automated value co-production of music content creation for composers with increased service productivity and customer satisfaction.
Problem solving strategy	• IT-Mediated CSS provides composer and the other individuals to collaboratively complete music content creation. • Self-regulating control can achieve evolution in matching rules. • Identifying CSS type: transactional marketplace service system.
Solution requirement	• Maximum satisfaction for addressing the composing problem derived from varied desired music contents provided by the other partners
Theories	• Adopting evolutionary theory for optimization: genetic algorithms and Fuzzy Rule.
Tacit knowledge	• The tags of a music database can be used to define the attributes of music contents (e.g., CDDB, ID3).
Design method	• Implementing a transactional marketplace service system that can match the best partner who is beneficial for music content creation of composing requests—iMusicCreation. • Semantic process (Ontology, RDF, XML, Semantic Web) • iMusicCreation includes the following service components: (1) ontology developer, (2) S-FGA partnership, and (3) co-created value appraiser for self-regulating control and IT-mediated CSS.

delivery process, i.e., the modeling of the service cognitive process and knowledge representations, must address the interactional value cocreation relationship and the specific characteristics classified while attempting to achieve maximum satisfaction and optimal productivity.

Evolutionary algorithms, regardless of whether they are coevolutionary or not, are population-based search methods based on biological evolution [50]. Biological evolution may be connected to our analogical mapping for purposes of service exchange and service delivery in a service system that incorporates adaptability and evolutionary algorithms in an ecosystem. Additionally, evolutionary algorithms often implement good approximate optimized solutions to various problems. This generality has been successfully applied in fields as diverse as engineering, economics, marketing, and robotics. In coevolution, an individual can also be evaluated by interacting with other evolving individuals [51]. Restated, aforementioned features of the evolutionary algorithms effectively address the service interactional relationship and the objectives of maximum satisfaction and optimal productivity. MBNSD thus adopts evolutionary algorithms to model the cognitive processes of CSS applications. However, applying evolutionary algorithms to model CSS applications involves designing appropriate service interaction protocols (in which the evolutionary algorithms are embedded appropriately) that correspond to each CSS application category. The three CSS applications described in Section V demonstrate the effective design of the interaction protocols.

In summary, the second phase offers an effective means of modeling and designing interaction-based CSSs. After one of the CSS classifications are identified based on its service provisions and tacit knowledge, the service providers and the system developers can first define the following six attribute elements, i.e., goal, problem solving strategy, solution requirement, theories, tacit knowledge, and design method. In this study, three novel service systems, i.e., iMusicCreation, iInteriorDesign, and iMobileDesign demonstrate the feasibility of using the proposed MBNSD approach to systematically model CSS applications, including music creation, mobile phone design, and interior design (see Tables IV, VI, and VII).

C. Phase III: Estimating and Managing CSS

This phase presents a novel approach to assess and manage service quality for CSS applications in terms of the CSQ measurements assessed by an IF function during service delivery [34] (see Fig. 7). In the MBNSD approach, the measurement can be integrated in many varied CSS applications to evaluate and manage their CSQ. In contrast with SERQUAL and E-S-QUAL [21]–[23], [29], [40], the CSQ measurements are based on IF values and can help manage the service experiences of users [20]. IF estimates the CSQ values during each service exchange within the service delivery process. Moreover, variations in IF values perceived by service participants can be detected throughout the service encounters.

If the CSQ measurements are implemented in a CSS, the system must predefine the domain-dependent determinants, i.e., significant service encounter factors, which would influence how its CSQ values, e.g., reliability and convenience, affect service encounters. Each CSS has a unique way of providing and exchanging services, as well as a tacit knowledge of a specific service industry. The IF values can be estimated using specified determinants of the CSSs. When customers feedback the numerical values that correspond to the specified determinants, the CSQ-aware CSSs can automatically use the corresponding determinant parameters X_i, where $i = 1, \ldots, n$, and their weights to calculate the IF values, i.e., $\mathrm{IF}_{(\mathrm{PR}),(\mathrm{ED})} = e^{[\alpha^T x]}$, where α denotes the weights and X represents the specified determinants. Restated, the specified determinants X should be predefined by the service providers based on the contents and context of the CSSs [13]. Additionally, CSSs differ in terms of determinants X as their specified determinant parameters to calculate their CSQ values (see Fig. 7). For instance, iMusicCreation is a CSS application that predefines the three specified determinants, such as the creativity, concretion, and integration

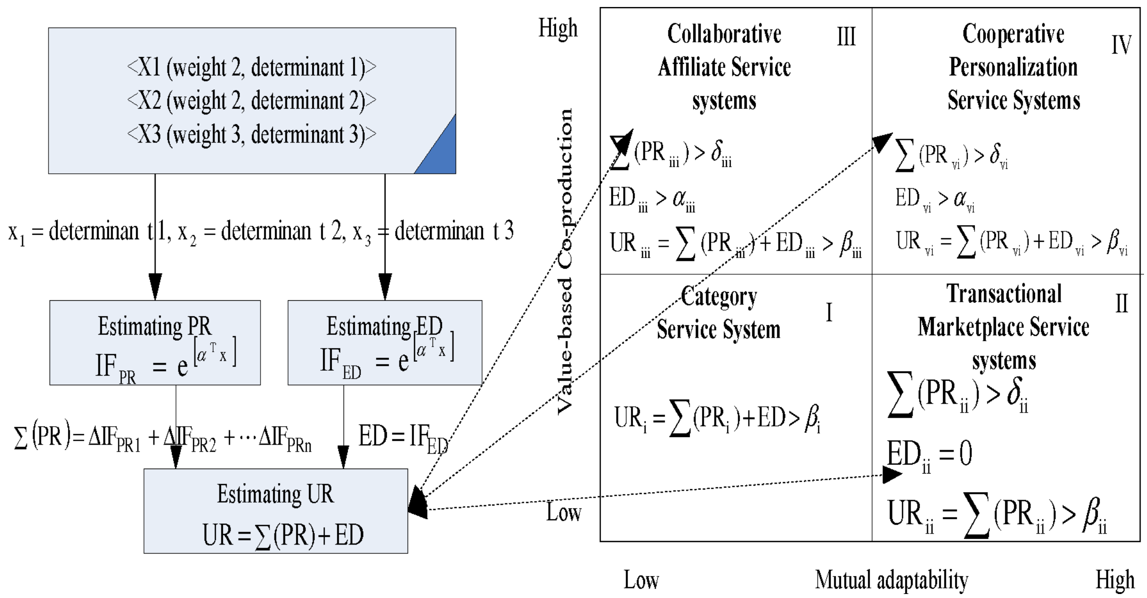

Fig. 7. Estimating and coordinating CSS.

(easy to integrate) for collaborative music creation (see Section V).

The parameter of $\mathrm{IF}_{\mathrm{PR}}$ determines the generated IF when providers and customers commence with service delivery. $\sum(\mathrm{PR}) = \Delta\mathrm{IF}_{\mathrm{PR}_1} + \Delta\mathrm{IF}_{\mathrm{PR}_2} + \cdots \Delta\mathrm{IF}_{\mathrm{PR}_n}$, where $\Delta\mathrm{IF}_{\mathrm{PR}_n}$ denotes the incremental value of IF from the service participants. $\sum(\mathrm{PR})$ denotes the total of all incremental IF values throughout their service encounters. Moreover, $\mathrm{IF}_{\mathrm{ED}}$ represents the loss of CSQ values once a partner (user) changes or drops. ED incurs the possible negative IF when the adaption decreases. The CSQ values change continuously, and the PR and ED can be assessed for monitoring the change of IF. Upon termination of the service, the ultimate response (UR) can determine the entire CSQ, i.e., $\mathrm{UR} = \sum(\mathrm{PR}) + \mathrm{ED}$. Notably, UR refers to the overall IF in the long run to assess the variation of CSQ during the service delivery process) (see Fig. 7).

According to MBNSD, CSS design and implementation initially involve identifying and determining the CSS type based on the four-category CSS classifications (as described in Section IV) with the four predefined distinct thresholds, as indicated within each classification shown in Fig. 7. The four threshold values are derived from the attributes of mutualism concepts (from low to high mutualism). Restated, the four sets of threshold values can be used to determine whether the users' CSQ values can achieve the respective goals of the CSS applications. These threshold values utilize the IF of proximate response (PR), evolved dependence (ED), and UR to estimate the individual CSQ values for the four CSS's types.

1) *Type I:* Category service systems indicate that the most general service industry is the service exchanges of low-level value cocreation but still complies with a certain CSQ ($\mathrm{UR}_{\mathrm{i}} = \sum(\mathrm{PR}_{\mathrm{i}}) + \mathrm{ED} > \beta_{\mathrm{i}}$).
2) *Type II:* Transactional marketplace service systems refer to the marketplace service in which the users (i.e., unfixed partners) can freely and voluntarily adaptively engage service exchanges for value cocreation ($\sum(\mathrm{PR}_{\mathrm{ii}}) > \delta_{\mathrm{ii}}$) without the influence of anyone's absence ($\mathrm{ED}_{\mathrm{ii}} = 0$) and comply with certain threshold values of CSQ ($\sum(\mathrm{PR}_{\mathrm{ii}}) > \delta_{\mathrm{ii}}; \mathrm{ED}_{\mathrm{ii}} = 0; \mathrm{UR}_{\mathrm{ii}} = \sum(\mathrm{PR}_{\mathrm{ii}}) > \beta_{\mathrm{ii}}$).
3) *Type III:* Collaborative affiliate service systems indicate that the provider collaborates with the customers adaptively to engage in service exchanges of high-level value cocreation that comply with certain threshold values of CSQ ($\sum(\mathrm{PR}_{\mathrm{iii}}) > \delta_{\mathrm{iii}}; \mathrm{ED}_{\mathrm{iii}} > \alpha_{\mathrm{iii}}; \mathrm{UR}_{\mathrm{iii}} = \sum(\mathrm{PR}_{\mathrm{iii}}) + \mathrm{ED}_{\mathrm{iii}} > \beta_{\mathrm{iii}}$).
4) *Type IV:* Cooperative personalization service systems indicate that a provider and a customer become fixed partners for service exchanges involving the cocreation of high-level value with the adaptabilities and comply with certain threshold values of CSQ ($\sum(\mathrm{PR}_{\mathrm{iv}}) > \delta_{\mathrm{iv}}; \mathrm{ED}_{\mathrm{iv}} > \alpha_{\mathrm{iv}}; \mathrm{UR}_{\mathrm{iv}} = \sum(\mathrm{PR}_{\mathrm{iv}}) + \mathrm{ED}_{\mathrm{iv}} > \beta_{\mathrm{iv}}$) (see Fig. 7).

In practice, these threshold values can often be predefined based on earlier experiences. Notably, the positive CSQ values can be verified when an estimated IF complies with the predefined threshold values. While an estimated IF violates the predefined threshold values, certain service recovery practices, e.g., increasing the intensity of some determinant parameters, can be implemented; in addition, CSQ can be measured continuously until the CSQ values comply with the threshold values. Restated, the CSQ measurements can enhance the service experience quality within a service exchange process. Meanwhile, whether the service provisions allow the service participant to foster partnership over time like species' mutualism and adaptability can be monitored based on CSQ measurements. Additionally, service productivity $\mathrm{E}(\mathrm{IF}_g)$ can also be determined as $E(\mathrm{IF}_g) = E(\bar{R}/L)$, where $\overline{R}$ denotes the service outcome (UR), and L denotes the service input (service costs) (see Table V).

TABLE V
EXAMPLE OF iMUSICCREATION'S CSQ

Interactive frequency	x_1	x_2	x_3	$e^{[\beta^T x]}$
1	0.36	0.32	0.28	$e^{0.96}$= 2.61
2	0.21	0.16	0.16	$e^{0.53}$= 1.70
3	0.03	0.02	0.02	$e^{0.07}$= 1.07
4	0.16	0.10	0.12	$e^{0.38}$= 1.46
5	0.24	0.18	0.18	$e^{0.60}$= 1.82

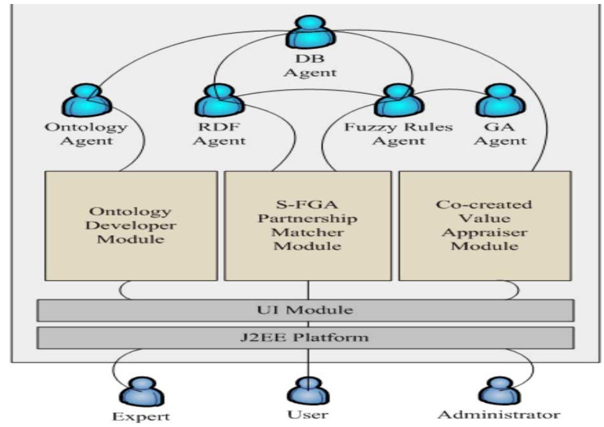

Fig. 8. System architecture of iMusicCreation.

V. CASES THAT DEMONSTRATE THE FEASIBILITY OF COLLABORATIVE SERVICE SYSTEM APPLICATIONS

Three CSSs demonstrate the feasibility of using MBNSD by applying it retroactively to three CSSs. In the first CSS, i.e., iMusicCreation, the design of a CSS for a collaborative music creation solution is described [36]. The second service system, i.e., iInteriorDesign, describes an application design involving collaborative interior design [5]. Finally, the third service system, i.e., iMobileDesign, designs and develops a CSS that facilitates a customer-centric idea management process for a mobile phone design company [32]. In each case, the MBNSD approach is adopted to display the process of designing, evaluating, and communicating with the artifacts. However, owing to limited space, the first case is described in more detail than are the second and third cases.

A. *Case 1: iMusicCreation*

Music creation is a knowledge-intensive system for musicians or amateurs. iMusicCreation offers a collaborative music creation platform. iMusicCreation facilitates collaboration to address the problem of inspirations required for music creations. In terms of its objectives, iMusicCreation is a transactional marketplace service with high mutual adaptability and low continuity of coproduction that can be characterized by sharing thoughts and knowledge among many contributors during their short-term transient transactions within the marketplace.

iMusicCreation consists of six salient basic elements of service design (see Table III) prior to the CSS design. With the defined service concepts of iMusicCreation (see Table IV), the cognitive process refers to the systemic process of responding to music contents and then selecting a matching partner. Knowledge representation refers to music content definitions, such as music tags CDDB and ID3 from the music database. The defined basic elements of service design devising a collaborative marketplace service system for music content creation, based on use of three service modules (see Fig. 8), i.e., ontology developer, semantic-based fuzzy genetic approach (S-FGA) partnership matcher, and cocreated value appraiser, to fulfill service productivity and satisfaction objectives [36].

In this CSS, music is produced through service exchanges among participants. The required cognitive process for marketplace self-regulation is automated based on a S-FGA. The partnership matcher utilizes the semantic approach based on ontology addressing partial problems related to collaborative music creation. Service exchange relationships between providers and customers are identified via an alternative service component, i.e., the S-FGA Partnership Matcher, which matches partners using optimized rules. The rules evolve based on criteria of coverage, accuracy, and concision. The marketplace acts as a collaborative platform in which a creation can be displayed and selected by a consumer following partner matching. Fig. 9 illustrates the ontology and initial set of rules used in iMusicCreation. A competitive marketplace thus determines the product value by its price [36]. In the iMusicCreation (see Fig. 10), a customer can bid, purchase, and appraise music creations.

In iMusicCreation, the cognitive process of responding to music contents and selecting matching partners is modeled using the S-FGA evolutionary algorithms. The service interaction protocol then refers to a sequence of service exchange transactions that are facilitated indirectly by the marketplace's partner recommendations for customers before their music is produced by receiving music inspiration from their collaborating partners. Restated, during each service exchange transaction, the service delivery decision enabled by S-FGA is the optimized (good) partner recommendations in which optimization refers to the quality of the partner matching rules in terms of their coverage and accuracy.

iMusicCreation adopts the CSQ model to evaluate the value coproduction process, i.e., a sequence of service exchange transactions. Three encounter factors define the service system, i.e., diverse creativity (x_1), concrete level (x_2), and integrated flexibility (x_3), all of which can be factors x_i for determining $e^{[\beta^T x]}$ as the outcome of service performance for each interaction, i.e., PR, where β denotes the corresponding weight (i.e., 1 in this example), which depends on the level of significance among factors. The results of PR, i.e., $\mathrm{IF}_{\mathrm{PR}}$, are the IF per service exchange interaction $e^{[\beta^T x]}$ (i.e., 2.61, 1.70, 1.07, 1.46, and 1.82), as shown in Table V. Restated, iMusicCreation is an e-service in which several collaborators, i.e., service customers, can freely contribute their individual music content for a request of

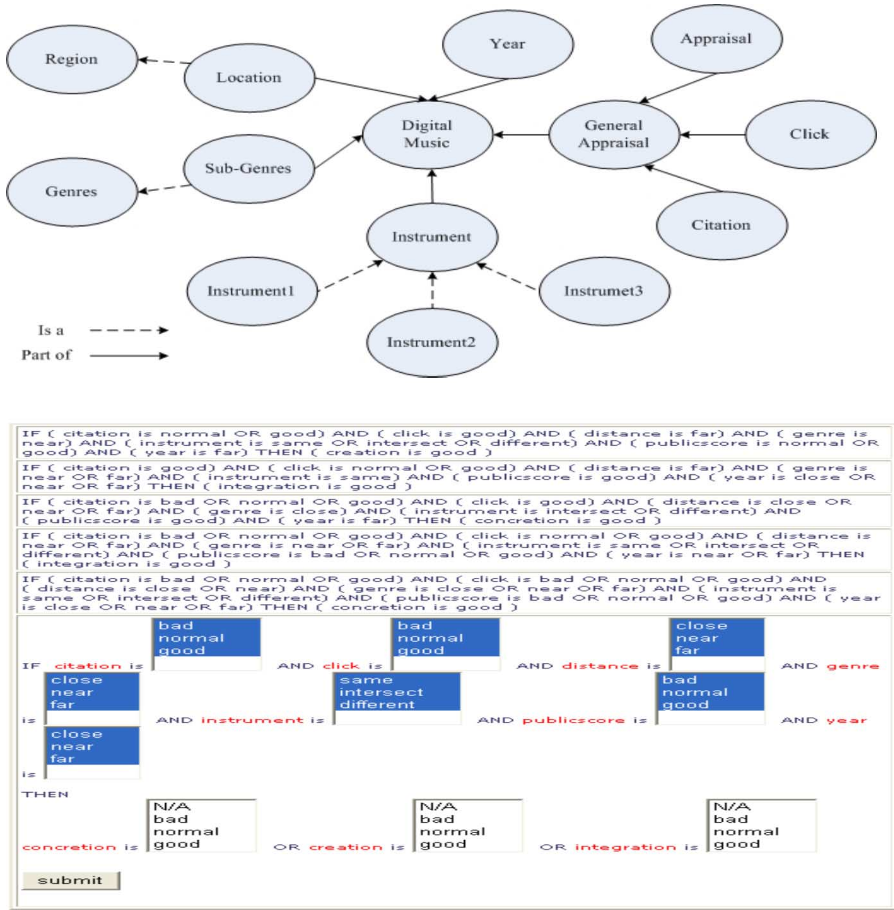

Fig. 9. Ontology and evaluation rules in iMusicCreation.

Fig. 10. Partner matching process in iMusicCreation.

music creation. Service interaction thus refers to a collaborator's contribution during music cocreation among the collaborators. According to Fig. 7, the sum of five collaborator's $\mathrm{IF}_{\mathrm{PR}}$ should be $\mathrm{IF}_{\mathrm{PR}} = F_0 + F_1 + \cdots + F_5$ ($\mathrm{IF}_{\mathrm{PR}} = 8.66$). The holistic service performance UR, i.e., $\mathrm{IF}_{\mathrm{UR}}$, is the sum of all $\mathrm{IF}_{\mathrm{PRs}}$ (e.g., $\overline{R} = \sum e^{[\beta^T x]} = 8.66$). When $\overline{R}$ is divided by the service cost L, (i.e., 5 in this example) the result in this case is positive service productivity, i.e., $1.73 > 1.0$.

Without a loss of generality, Table V lists five service change interactions during coproduction process. PR arises from the

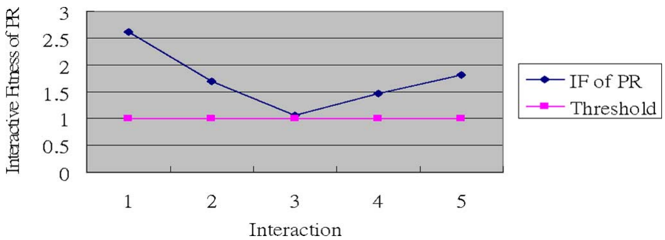

Fig. 11. Experimental results of $\mathrm{IF}_{\mathrm{PR}}$ and threshold value of PR.

five interactions, with each outcome, i.e., the encounters, regarded as a service performance/fitness during service delivery. According to Fig. 11, each $\mathrm{IF}_{\mathrm{PR}}$ can be examined against the threshold value of $\mathrm{IF}_{\mathrm{PR}}$, e.g., the average value of 1.0 in this example. Therefore, all interactions achieve fitness exceeding the criterion level of adaptability. $\mathrm{IF}_{\mathrm{UR}}$ is then calculated using all $\mathrm{IF}_{\mathrm{PR}}$. The fact that iMusicCreation encompasses several collaborations without long-term relationships for collaborative music creation explains why the service delivery process does not contain $\mathrm{IF}_{\mathrm{ED}}$. The results of $\mathrm{IF}_{\mathrm{UR}}$, i.e., 8.66, must be compared to determine whether the service performance exceeds the criterion of $\mathrm{IF}_{\mathrm{UR}}$, i.e., 5.0 in this example. This represents the service outcome and the relationship fit required by partnership (mutualism). For the threshold values of $\mathrm{IF}_{\mathrm{PR}}$ and $\mathrm{IF}_{\mathrm{UR}}$, the service managers are likely to assign values subjectively (e.g., the average CSQ values from an earlier application experience), depending on their service policy. For simplicity, this study defines the threshold values of $\mathrm{IF}_{\mathrm{PR}}$ and $\mathrm{IF}_{\mathrm{UR}}$ which attain the average performances of the previous service provisions. If the performance does not exceed the predefined thresholds, the service provider can identify the encounter factors that should be improved to increase the subsequent IF during service delivery. The system performance of iMusicCreation is superior to the conventional approach of a user searching for others' opinions from online communities and finding music pieces to become inspired in order to create new music [36]. System performance refers to the value-in-use service experience and CSQ is the metric used for the comparison.

B. *Case 2: iInteriorDesign*

iInteriorDesign provides a collaborative interior design service that ensures low communication costs by extracting the required interior-design key attributes (e.g., romanticism and luxury) and the optimization of the interior-design concept style selection (e.g., Victorian style, and minimal and luxury) with the assistance of a concept style ontology (of the concept style properties similar to region, era, category, climate, and culture), thus enabling the value coproduction relationships. According to the objectives of iInteriorDesign, this system is a cooperative and cooperative personalization service system (both sides—provider and receiver—exchange benefits to fulfill a high level of coproduction) that can be characterized by enabling both the designer and the customer to engage in coevolution and adaptation during extraction, thus satisfying customer requirements [5]. Table VI lists the six salient basic elements of service design.

iInteriorDesign utilizes an integrated CICGA in which the Cooperative coevolutionary GA (CCGA) generates key attributes of interior design from extraction process. Additionally, the interactive GA (IGA) can incorporate customer feedback to further optimize interior-design concept style selection. Thereafter, CICGA extracts optimal solutions via the interactive coevolution method and then inputs the results to the coevolutionary knowledge base. This CSS application comprises a defined ontology with the interior-design attributes and system architecture, including the knowledge base and the web-based system.

Based on the CICGA evolutionary algorithm, the cognitive process of generating interior-design concept styles is modeled in terms of decomposing the concepts into four subsets of concepts, i.e., the nonlayman terms as the light, water, stone, and tree used in interior design, while considering customer feedback. The service interaction protocol then refers to a sequence of service exchange transactions directly, as generated by these interior-design concept style recommendations for customers before their satisfactory interior-design concept style is attained. Restated, during each service-exchange transaction, the CICGA optimized (good) interior-design concept styles, while the optimization refers to how close the recommendations satisfy customer requirements.

For instance, iInteriorDesign continuously executes CICGA that can automatically select the optimization solutions until the estimated IF satisfies the predefined criteria when the results do not satisfy the criteria. In iInteriorDesign, CSQ can be estimated based on the three determinants (X) derived from the service feedback users perceived in service encounters and service provisions during the service process. iInteriorDesign involves the level of innovation (X_1), degree of content (X_2), and professional extent (X_3) as the determinants underlying the results of primitive interior design. The weighted average of all determinants from user feedback must be used to examine the default criteria, i.e., IF function of PR and UR, in order to ensure if they achieve an adequate CSQ. Meanwhile, service systems can also adjust to different determinants (or their values) and their corresponding weights in order to achieve satisfactory effects of value coproduction at various interaction points of the service process. For service-quality management, adjustment is a function of the CSQ model. For a service that emphasizes the level of innovation that can influence the results of collaborative works, the higher weight can be adjusted and defined. The original determinants can be adjusted or even dropped, depending on the level of significance or service characteristics. For instance, iInteriorDesign offers a design service that is derived from the professional ability of a designer. The weight of professional extent (X_3) exceeds the other two determinants X_1 and X_2. Importantly, iInteriorDesign can facilitate the determination of preliminary design styles, reduce service exchange barriers, and achieve design requirements through a single case-study method [5]. Additionally, the system performance of iInteriorDesign is superior to that of the modeling approaches using only CCGA or only IGA. Moreover, system performance refers to the value-in-use service experience, in which CSQ is the metric used for comparison.

TABLE VI
DESIGNING AND MODELING IINTERIORDESIGN

Basic Elements of Service Design	Tactic for Designing and Modeling CSS—iInteriorDesign
Goal	● Automated value co-production of the decision style of an interior design project between interior designers and customers with increased service productivity and customer satisfaction.
Problem solving strategy	● IT-Assisted CSS that can provide an effectively interactive interior design service process. ● Identifying a CSS type: collaborative affiliated service system.
Solution requirement	● Extracting the pertinent concepts and attributes of interior design based on minimum communication costs and maximum satisfaction
Theories	● Co-evolutionary theory for Optimization: Combine Cooperative Co-evolutionary GA with Interactive GA for CICGA.
Tacit knowledge	● Attributes, concepts, and styles of preliminary interior design
Design method	● Implementing a cooperative personalization service system that can provide interior designers and customers to optimize the style concepts associated with decisions based on customer requirements—iInteriorDesign. ● Self-regulating control by adopting the interactive co-evolutionary approach to extract optimal style concepts of interior design. ● iInteriorDesign includes the four service modules: (1) design problem specification, (2) design recommendation, (3) cooperative interactive co-evolutionary GA, and (4) evaluation for determining the optimized style concepts of interior design.

TABLE VII
DESIGNING AND MODELING CSS— IMOBILEDESIGN

Basic Elements of Service Design	Tactic for Designing and Modeling CSS -- iMobileDesign
Goal	● Automated value co-production of ideation management for mobile phone design between mobile-phone companies and customers with increased service productivity and customer satisfaction.
Problem solving strategy	● IT-facilitated CSS that can provide an effective ideation management of mobile phone design. ● Identifying a CSS type: collaborative affiliate service system.
Solution requirement	● Reducing communication costs of determining the productive elements of mobile phone design.
Theories	● Mathematic models of Mutualism theories and evolutionary approach to optimize the feasibility of productive ideations of mobile phone design in a business process [13].
Tacit knowledge	● Business process of ideation management of mobile phone design ● Features of mobile phone and its design's domain know-how.
Design method	● Implementing a collaborative affiliate service system can provide mobile phone companies and automatically optimize customer requirements for ideation management of mobile phone design — iMobileDesign. ● Systematic business process of mobile phone design including problem conceptualization, concept visualization, and design commercialization. ● iMobileDesign includes the four service components in place of the practical business process of ideation management: (1) ideation module, (2) competition module, (3) mutation module, and (4) monitoring module

C. *Case 3: iMobileDesign*

iMobileDesign applies MBNSD to facilitate the business process of idea management in mobile phone design, thus facilitating customer-driven design in which a mobile phone company can not only focus on customer concerns to retain the originality of a customer's idea but to sustain process feasibility to achieve product design as well. Based on the objectives of iMobileDesign, this is a collaborative affiliate service system, in which one side-–provider—exchanges services as a collaborative service to achieve high value coproduction. iMobileDesign can be characterized by integrating the efforts of the service provider efforts. Table VII lists the six salient basic elements of service design.

iMobileDesign models and automates the required business procedures involving the idea management of mobile phone design through the means of evolutionary algorithms, making it feasible to apply CSS to the idea management of mobile phone design. Mobile phone design encompasses a series of service activities that are performed as the intelligent system of idea management. Based on the mutualism-based theory and evolutionary algorithm, this study also proposes mathematical models and develops a system that consists of four service components to facilitate interaction-based collaborative service interactions and service delivery. These models determine the optimum offspring of design proposals over collaboration and competition evolution. The four service components include the ideation module, competition module, mutation module, and monitoring module to achieve the strategy and value activities involving the idea management of mobile phone design.

Evolutionary mathematical models can represent the cognitive process of conceptualizing a problem for idea management in terms of a semiautomatically assisted decision-making process in which ideas from different stakeholders are incorporated in mobile phone design [32]. The service interaction protocol thus refers to a sequence of service exchange transactions that are facilitated indirectly during a nonshort term of service delivery process. Restated, during each service exchange transaction, decisions made by evolutionary mathematical models are the optimized (good) idea proposal choices recommendation. Moreover, the optimization refers to how closely the recommendations match customer preferences.

iMobileDesign uses CSQ measurements to assess the value coproduction process. The service system defines customer idea probability (CIP) as the estimated performance of design proposals, which can be assumed to be the factors x_i involved in calculating $e^{\left[\beta^T x\right]}$ as the outcome of service performance for each interaction, i.e., PR. Then, CIP is calculated as the average percentage of preferred customer ideas incorporated in the design proposals. iMobileDesign is also benchmarked against traditional idea management for mobile phone design by estimating CIP at each service process checkpoint. Simulation results indicate that the iMobileDesign performs better than conventional methods in terms of mediating idea management of mobile phone design [32]. System performance refers to the value-in-use service experience. CSQ is the metric used for comparison.

VI. Managerial Implementations of Mutualism-Based New Service Development

The NSD method developed in this study contributes to service industry to adopt the innovative and systematic method. MBNSD is an analytical and synthetic approach that encompasses the three phases to construct CSS applications that are empowered in order to achieve automating value coproduction. Additionally, three CSS cases demonstrate the feasibility of identifying CSSs' classification, modeling CSSs, and managing CSSs. Thus, the three CSS cases reveal how the CSSs can be modeled and designed based on the NSD method (see Fig. 12).

For the conceptual metaphor of ecology mutualism, this study adopts the analogy of ecological mutualism concepts and mutualism assessments in natural science [18] and then applies them to CSS development and its quality evaluation in social science. Although current NSD methods offer various procedures and methods, e.g., TRIZ, Fraunhofer IAO, and SEE, this study contributes to efforts to devise a quantitative NSD method and IT-enabled models for constructing CSSs. In the designed CSSs, the three measurements of IF of PR, ED, and UR are also introduced and embedded into these CSSs. Restated, estimating the IF for CSQ evaluations must be related to the service processes within the CSSs. The assessment model can be characterized by quantifying capability, i.e., the CSQ can be estimated as to whether they satisfy the objectives of constructing a collaborative relationship, and managing capability, i.e., the CSQ can be estimated to verify or further adjust the service provision during service delivery.

For modeling CSS, these CSSs in the classification matrix mainly use evolutionary algorithms, e.g., GA and CICGA, to facilitate collaborative service exchanges directly or indirectly. Simultaneously, their CSQ are estimated based on the service interaction protocols. Restated, in addition to enforcing the automated service exchanges with appropriate service optimization decisions within service delivery, e-services can foster collaborative relationships during service exchange.

With respect to managerial implications for service science research, the multidisciplinary NSD method for CSS application designs in the service industry and service stakeholders is important in terms of its impact on current NSD methods in academia and its impact in terms of emerging opportunities in the service industry.

As For its impact on current NSD methods in academia, this study contributes an effective automating value coproduction and systematic service innovation and, in doing so, advancing service science research. MBNSD's values depend on a three-phase design method and a quantitative service-quality model. Moreover, estimating the CSQ contributes to monitor service quality in CSSs. Based on the four-category classification matrix, CSSs can be first determined as the design principles of CSS. The second phase, modeling CSSs, can facilitate/mediate/generate e-services by using optimization methods and evolutionary algorithms. Consequently, the determinants used in CSQ depend on the service business model in CSS applications.

As for its impacts on MBNSD in the service industry, this study provides a valuable reference for e-service design and individuals concerned with incorporating CSSs in customer service. The service industry can implement the SOM of CSS applications to elucidate the mutualistic interdependence behaviors in the service exchange processes and service encounters involving CSSs. Additionally, the three cases of CSSs, i.e., iMusicCreation, iInteriorDesign, and iMobileDesign, provide a valuable reference for CSS applications of MBNSD. We believe that most e-service providers can enhance their services by facilitating the automation of value coproduction with the MBNSD approach and expanding the number of NSD stakeholders.

VII. Conclusion

This paper presented a MBNSD method that is capable of constructing CSSs and its SOM in order to automate value coproduction. The three-phase design procedures of MBNSD described how service providers and customers can exchange services to foster their collaborative relationships and make decisions regarding service exchanges within service delivery in order to automate value coproduction and systematic service innovation. The proposed MBNSD method also incorporatesd a service-quality model that can determine the CSQ within the service delivery of CSS.

As for the conceptual metaphor of mutualism, we believed that the mutualism in ecology among species resembles

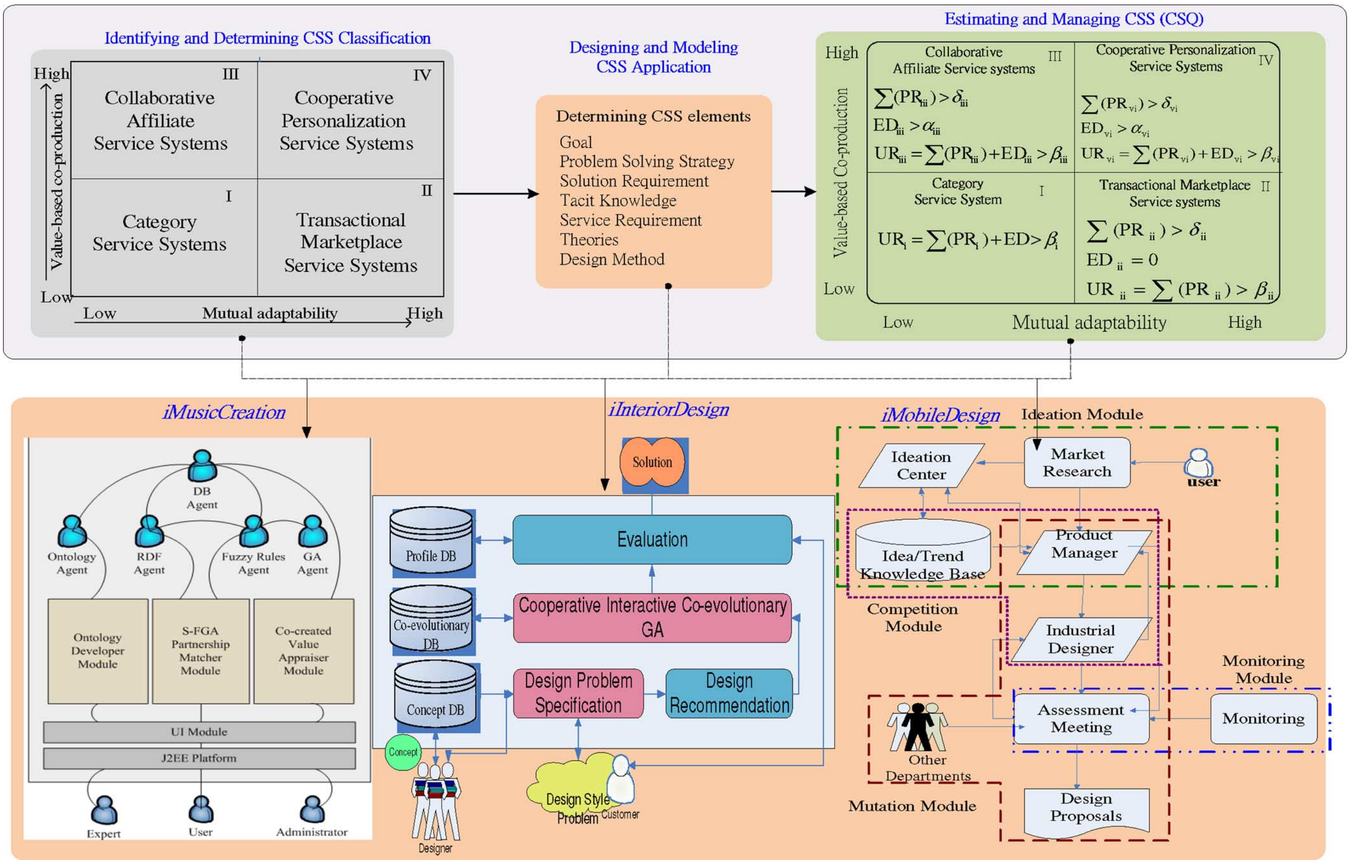

Fig. 12. Holistic view of MBNSD for constructing CSS applications.

cooperation among individuals in a service system. The species could coevolve over time to adapt each other. According to the metaphorical insight of mutualism, the CSS could create an interactive service that can achieve the objectives of the win-win value coproduction. Since the different capabilities of species could evolve and change over time, the survival probability of a species could also be raised along their evolution and adaption. According to the conceptual metaphor, multidisciplinary research was undertaken for the study of service science. This study then presented a novel MBNSD approach that incorporates the ecological mutualism concepts and assessment theory into the design principles of CSS applications. However, the evolutionary algorithms or optimization methods could also be modeled for service decisions within CSS based on the design principles analyzed herein. Moreover, the proposed method addresses the feasibility of developing CSSs based on the four categories of CSSs and the design principles of CSS in order to automate value coproduction and achieve innovative and systematic services. Furthermore, service quality can be evaluated to adequately control the collaborative service process and enhance service performance quality between service providers and customers within service delivery.

The proposed MBNSD method empowers system engineering and management iteratively based on the use of the three-phase procedures. The first phase classified and determined the CSS types that enable service managers and system developers to identify which CSSs are their desired e-services, i.e., category services, transactional marketplace services, collaborative affiliate services, and cooperative personalization services. The innovative CSS design principles can be characterized based on the CSS classification.

The second phase involved the use of a modeling approach to automate the value coproduction of SOM in order to achieve systematic service innovation. Symbiosis-aware adaptive approaches and evolutionary methodologies, e.g., GAs, could also be adopted to develop the automation of value coproduction for win-win. Also, various evolutionary methods could be used to optimize their decisions and interactions in order to reach value coproduction between service providers and customers. However, customer input was critical to service exchanges, service processes, and service delivery with value coproduction. Modeling and automating were thus referred to as the representations of cognitive process required to facilitate collaborative service exchanges involving customer input.

In the third phase, CSS required a prerequisite for estimating CSQ. Notably, the specific criteria of CSQ are interpreted based on the theoretical foundation of mutualistic criteria. To ensure service quality, CSS must also integrate an evaluation model to monitor the collaborative service and further improve service operations.

Furthermore, three cases demonstrated the feasibility of applying the proposed MBNSD method to devise CSS applications. Although the cases belong to a specific service sector of design, e.g., music creation, interior design, and mobile phone design, the values of the MBNSD method appear to be well justified. However, other e-services applications should have specific service factors for determining CSQ.

Meanwhile, MBNSD method is designed for e-services, and is not intended for physical services, e.g., restaurants and transportation, in addition to addressing some of the inadequacies of the NSD method or extend its applications [45]. Future research should also introduce additional multidisciplinary fields to develop a basic classification for NSD models. CSQ is occasionally evaluated based on numerous intangible factors, including user cognition and impressions. A further investigation would require such significant factors to evaluate CSQ that influence the service performance. Research that focuses on the aforementioned aspects would significantly contribute to efforts to fully understand CSSs and SOM that is involved in assessing the service performance of value coproduction. Despite the use of prototypes in this study to demonstrate the effectiveness of mutualism-based CSSs, further empirical studies could further validate the reliability of the proposed models through additional samples involving actual service exchanges between providers and customers.

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