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Collaborative service system design for music content creation

Wei-Feng Tung · Soe-Tsyr Yuan · Yen-Cheng Wu · Patrick Hung

Abstract This article presents a novel collaborative service system (CSS) design methodology supporting the work of multiple participating users and collaborative services processes. The CSS application of music content creation paradigm called *DesignStorming* as it pertains to CSS modeling and developing. CSS is an interactive service system that can be systematic service innovation and automatic semi-automated value co-creation between service providers and customers to enhance service productivity. The objectives of this research are threefold—to propose a novel design methodology for CSS, to incorporate simple service machine (SSM) and intelligent service machine (ISM) for CSS, and to demonstrate a CSS application of music content creation. SSM is a road map that can be used to define the salient attribute elements for CSS design. According to the predefined SSM, ISM conducts modeling the cognitive process of service exchanges and service provision, their knowledge representations, and value co-production process for a computerized CSS. *DesignStorming* demonstrates how a CSS can be automated the interactive communications and problem solving processes during the music content creation work. The CSS application involves the three system components: 1) Ontology Developer, 2) SFGA Partnership Matcher, and 3) Co-created Value Appraiser. In addition, a service evaluation model is described and evaluated, so that some of their important characteristics can be identified. Such a comprehensive design methodology can provide the foundation for building future more diversified and innovative collaborative service system.

Keywords CSS · Service science · Collaborative service systems · Intelligent service machine · Semantic-based fuzzy genetic algorithm · Semi-automated value co-creation

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1 Introduction

Major economies around the world have experienced phenomenal shifts from manufacturing-based industries toward service-focused businesses (Frei, 2008). This economic structure of service systems has steadily increased in complexity in recent years (Caswell et al., 2008). The roles of producer and consumer are not distinct; rather, they interact jointly and reciprocally to co-create value through the integration of resources and application of competences (Vargo and Lusch 2008) Service-dominant (S-D) logic is central to service science and to the study of value creation in service systems (Oh & Teo, 2010). Service-delivery systems and service-dominant logic strategies are fundamental to the emerging discipline of service science (Marglio and Spohrer 2008). This article describes a novel design methodology for collaborative service systems (CSS). CSS is one type of the interactive e-services which can automate service process of

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value co-creation between service providers and customers to enhance service productivity.

In the context, the main contributions of this research are threefold. First, it proposes a new design concept and methodology of CSS for design science research. Second, it incorporates simple service machine (SSM) and intelligent service machine (ISM) for CSS designing and modeling. Third, it demonstrates a CSS application of music content creation designed and developed by SSM and ISM called *DesignStorming*.

With respect to the first objective, the research is to provide a design concept and methodology for CSS, which can be defined as e-services supporting the work of multiple participating users or collaborative services.

The second objective is to discuss SSM and ISM for CSS design. We use the metaphor "machine" to explain the empirical phenomenon of "service productivity" by considering service input and service outcome. By using the metaphor of machine, we also emphasize that describing and understanding service productivity always relates to a collaborative service perspective. Machine is often to associate with the efficiency and effectiveness of manufacturing. The proposed CSS design methodology begins with the SSM. According to the defined SSM, intelligent service machine (ISM) conducts modeling and automating the value co-creation between service providers and customers in the service process to enhance service productivity.

The third objective is to develop a CSS application. *DesignStorming* adopts the optimized decision-making methodology of the Semantic-based Fuzzy Genetic Algorithm (SFGA) to determine optimal partnership matching of the users of the service. SFGA is a self-regulating control that enhances the whole collaborative service process of creating music content. *DesignStorming* contains three service components: Ontology Developer, SFGA Partnership Matcher, and Co-created Value Appraiser. Its users can match with and query other service participants who can really help solve their problems concerning the creation of music content. In order to address the various problems of the creation of music content, the system adopts one type of e-marketplace to provide a CSS of music content creation. *DesignStorming* provides an interactive service platform for cooperative music content creation and makes it easier for composers to acquire ideas to help them create music content.

This paper explores a music content creation paradigm as it pertains to CSS design and modeling. Among the system design issues, the CSS used is identified as being of particular importance. This article describes how the CSS design methodology contributes to the future of service system design research.

The rest of the paper is organized as follows: in Section 2 we discuss the research background; in Section 3, we present a CSS design and development using SSM and ISM; in Section 4 we demonstrate a CSS application– *Designstorming*; in Section 5 we discuss the implication; and Section 6 concludes the paper.

2 Research background

The increasing importance of information technology (IT) services in the global economy prompts researchers in the field of information systems (IS) to give special attention to the foundations of managerial and technical knowledge in this emerging arena of knowledge (Bardhan et al., 2010). Current research in IT and computer science has examined issues in services management (Cox & Kreger, 2005) and service-level agreements (Benaroch et al. 2010) etc., With regard to the service-oriented enterprises, they establish services-oriented business and architecture with loosely coupled services and integrated value chains (Zhao et al., 2007). This section describes the research background of service science, management, and engineering (or service science) research. The goal of SSME (or service science) research is to automate value co-creation and systematize service innovation to improve service productivity and customer satisfaction. This section also discusses the importance of collaborative service systems (CSS) that can improve service productivity.

2.1 Automatic value co-creation to improve service productivity

Service science, management, and engineering (or service science) explore how to align people and technology effectively to generate value for both services providers and clients (Allen et al., 2006). On the other hand, service science co-creates values by combining business and governmental capabilities to improve service, evaluates information technology and tools, and investigates enterprise culture. Value co-creation is a beneficial exchange in that it eliminates redundant transaction costs and improves coordination between clients and providers (Spohrer et al., 2007). Interventions are performed to transform a state, to co-produce value, and to constitute services (Maglio et al., 2006). These advances can be exploited to encourage and unify employees, as well as to achieve total service effectiveness (Zeithaml et al. 1993). Sheehan and Stabell (2006) indicate that the creation of higher value is associated with the increased reputation of a service. Caswell et al. (2008) propose that they calculated the total value such service systems generate, taking into account the value accrued due to the transfers of offerings as well as the expected value due to the partners' satisfaction in the various relationships. For retailers, understanding consumers' value-creating processes is a prerequisite to offering value propositions for consumers (Payne et al., 2008). Spohrer & Maglio (2008) propose a research framework for studying work evolution in service systems. With services thinking, companies co-create their offerings with customers and break process silos into modular services that can be reused in loosely coupled services systems or out-tasked to external providers (Demirkan & Goul, 2008; Demirkan et al., 2008). However, service systems are value-creation networks composed of people, technology, and organizations. Thus, this research showcases an innovative CSS design whose objective is to supply the semi-automated value co-creation that is referred to in SSME.

2.2 Systematic service innovation for CSS

Service science aims to understand and catalog service systems and apply that understanding to advance particular abilities. These abilities include designing, improving, and scaling service systems for practical business and societal purposes (Spohrer et al. 2007). Nevertheless, the service scientists must address the problem of creating service innovations and improving the service system (Maglio et al. 2006; Bitner and Brown 2006). Spohrer et al. (2007) indicates that a service system is comprised of people and technologies that adaptively compute and adjust in order to meet a system's changing value in terms of knowledge. Service systems comprise service providers and clients working together to co-produce substance in complex value chains or networks (Tien & Berg, 2003); their characteristics evolve over time as service system scientists attempt to improve their productivity, quality, compliance, and innovation (Spohrer et al., 2007). In terms of service activities, service systems are complex adaptive systems involving consumers (Spohrer et al., 2007). Customers, as service process participants who are well-grounded in current state-of-the-art service innovation, require attention in order to facilitate the service system design; this element is not found in manufacturing operations (Fitzsimmons & Fitzsimmons, 2004). Thus, this research focuses on CSS design and development.

Emerging service delivery has three main characteristics: (1) people are the service stakeholders involved in service activities in the service encounter, (2) IT is the supply material, and (3) information resources enjoy an incredible efficiency scale because of the small incremental cost in duplicating these resources (Spohrer et al., 2007). Zeithaml et al. (2009) indicate that hybrid commerce offers the ultimate form of customer participation in a service-delivery system. A study (Ray et al., 2005) that proposed a cooperative management methodology for enterprise networks (CoMEN) suggested how the classification and modeling of human roles and the analysis of some representative scenarios could lead to the identification of gaps in existing collaborative environments. Boongasame & Daneshgar (2011) propose that a collaborative platform for buyer coalition using the Awareness-based Buyer Coalition (ABC) system. However, CSSs comprise people, technology, and both internal and external service systems that can share information. CSSs also include self-service technology, which impacts customer satisfaction and the multi-dimensional measure of consumer commitment (Beatson et al., 2007). Companies are experiencing increasingly developed collaborative relationships with other organizations in order to stimulate new thinking, creativity, and service innovation (Bitner & Brown, 2006). Thus, this research aims to provide a new concept and methodology for systematic service innovation for CSS engineering.

3 CSS design and development using SSM and ISM

SSM and ISM can enhance the design and development of CSS, which enables semi-automated value co-creation between service providers and customers. The design concept and methodology strives toward modeling and automating the cognitive process and knowledge representations that can be applied to various design services. Traditional machine cognition involves mechanical parts, while distributed cognition is the manufacturing cognitive process that considers the functional relationships of the parts that are included in the manufacturing process. A service system can be viewed as a container that holds a service encounter, service process, and service delivery (Imaz & Benyon, 2007). The subsections discuss SSM based on social technical systems (STS) and the relationship between SSM and ISM

3.1 Simple service machine based on social technical system

Bostrom and Heinen (1977) state that a social technical system (STS) is a system composed of both technical and social subsystems. A physical example is a hospital where people are organized into social systems such as teams or departments to perform tasks using technical systems such as computers or x-ray machines. In other words, a service system is composed of two joint, but still independent, social and technical systems. A service system is a set of complementary or interdependent information systems whose objective is to optimize both social and technical systems (Lamb & Kling, 2003) jointly.

The design method refers to modeling and automating the service process that involves people, model, architecture, and technologies. Simple service machine (SSM) can facilitate the identification of factor combinations and the interactive effects among these factors. Based on STS theory (Bostrom & Heinen, 1977), a service system also has several factors that affect social and technical service interactions (Fig. 1). Bijker (1995) states that causal technical and social elements shape the interactions of all relevant factors and actors, while at the same time influencing the trajectory of technological and social systems. The salient attribute

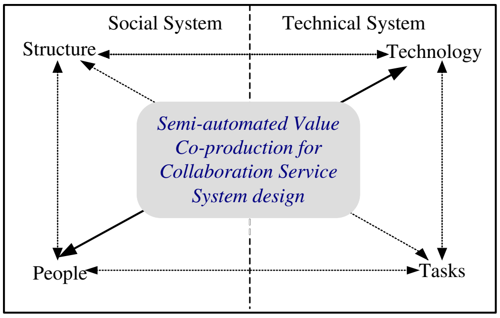

Fig. 1 The concepts of collaboration service system design based on STS

elements of STSs include goals, problem solving strategy, solution requirements, theories, tacit knowledge, and design methods. Moreover, Bijker (1995) argues that a technological framework comprises elements that influence interactions within relevant social groups and lead to an attribution to artifacts (i.e., information systems). Therefore, an information system should consider the attribute elements, such as the parts of social systems and the parts of technical systems for modeling and automating the information processes of independent subsystems, their interactions, and the comprehensive process.

Given STS, a CSS design consists of the six attribute and elements that embody it. First, the goal is to raise the level of service productivity by means of semi-automated value co-creation. Second, a problem-solving strategy can be facilitated, mediated, or assisted by collaborative or self-service technology. Third, the solution requirement seeks to minimize cost, maximize productivity, or both. Fourth, an adopting theory can be derived from many varied disciplines (i.e., natural science or social science theories). Fifth, the service process involves a variety of tacit information, knowledge, and the decisions of the people involved. Sixth, the design method can use the concept of design science to build a synthesized IT-artifact (i.e., IT-enabled service system) characterized by its goals, service operation, measurable functions, and adaptability (Table 1).

Table 1 Attribute elements of SSM

Attribute elements	Tactic of developing CSS applications
Goal	Enabling semi-automated value co-creation between the service providers and customers
Problem solving strategy	Facilitated/mediated/assisted collaborative technologies
Solution requirement	Increased service productivity
Theories	Interdisciplinary theories or methodologies
Tacit knowledge	Domain knowledge and information as well as the decisions of people involved
Design method	Design-science approach (synthesized IT-artifact)

3.2 ISM based on SSM

An ISM aims at modeling and automating the cognitive process and knowledge representations that can be applied to design problems. A CSS comprises interactions between service providers and the customers who can co-produce the values. Their dynamics are driven by the constantly shifting value of knowledge distributed between the customers and providers. To serve this purpose, ISM is an approach to modeling and automating the particular cognitive processes and knowledge representations (in the case of *DesignStorming* involving the collaborative creation of music content), that is characterized by salient elements of embodied theories that support the value co-creation process, underlying the development of optimal productivity. With reference to the system modeling of e-services, for example, Etzion et al. (2005) presented a modeling approach for the calculation of customer value in the e-Commerce realm, and a learning algorithm that aids in generating this model. An ISM is derived from theories embodied within the social-technical aspects of an SSM, and helps equip it so that it can improve e-services, and provide high service productivity.

4 CSS application — *DesignStorming*

CCSs, typically e-services, enable semi-automated value co-creation for service users. Composing music is knowledge-intensive work for both the specialist and the amateur. However, a CCS whose purpose is to assist its users to create of music content should be a novel application of a service system innovation. *DesignStorming* adopts a CSS design that is capable of enabling people to combine their efforts to address problems related to creating music content. The system enables a user to acquire various responses from other service users by coordination, and systematically looks for the optimal partners who can assist each other in the problems of music creation. However, the service system particularly tackles musical knowledge inquiries, for example, music content originality and inspiration. Semantic description processes are also designed and conducted in order to optimize the partner matching. To develop a CSS of music co-creation, *DesignStorming* exploits three service modules: Ontology Developer, SFGA Partnership Matcher, and Co-created Value Appraiser, which match the optimal partners. This section demonstrates how both SSM and ISM are used to develop CSS to create a service system innovation with semi-automated value co-creation for music content creation.

4.1 Simple service machine of *DesignStorming*

In the metaphor, the machine represents the construction parts in the field of manufacturing. SSM can thus be defined as the construction parts of a CSS. The salient attribute elements of a CSS that is being developed are, by analogy, the parts of the service machine. The following sections describe how a CSS with semi-automated value co-creation can be designed to increase service productivity. There are six attribute elements: goals, problem solving strategies, solution requirements, theories, tacit knowledge, and design methods. To supply the requirements of collaborative music content creation, the design methodology pre-defines the six salient attribute elements for the SSM of *DesignStorming*, and further develops its ISM (Table 2).

(1) Goal

For a computerized service system to support music co-creation successfully, it should fit the decision situation that users should be able to discover optimized partners to solve their problems related to composing music appropriately.

Table 2 SSM of design storming

Attribute elements	Tactic for developing CSS of music creation
Goal	• Develop an innovative collaborative service system enabling systematic decision-making for matching the optimal partners who can provide the adequate music content for the specific music creation problem.
Problem solving strategy	• Mediate collaborative service interactions and processes that can use information technology and the optimal algorithm to provide a service to customers and providers, respectively. • Self-regulating control refers to evolution of matching rules. • *DesignStorming* adopts Ontology Developer, SFGA Partnership, and co-created Value Appraiser for mediated collaborative service and self-regulating control • Optimization methodologies (Fuzzy Rule, Genetic Algorithm; GA) • Semantic process (Music Content Ontology, RDF,XML)
Solution requirement	• Increase service productivity and address the problems of music creation provided by other service users (partners)
Theories	• Use ‘evolution theory’ and the related algorithms in information science field for optimizing the decision-making problems
Tacit knowledge	• Utilize an existing database of musical tags to define music content Ontology’s attributes (e.g., CDDB, ID3)
Design methodology	• Adopt a design science approach (Havner et al., 2004) • Develop a synthesized IT-artifact (i.e., the system prototype of collaborative music content—*DesignStorming*)

- Automating partner matching: The service system provides the availability of a matching partner for music co-creation based on the process of collaborative interactions and comparisons. Thus, the e-marketplace that is provided has a self-regulating auction control that can supply semi-automated value co-creation.
- Evaluating service productivity: The service system also provides a value appraisal to evaluate productivity during the process. Thus, a service component of value appraisal can be used to assess music content that users have recommended.

(2) Problem solving strategy

The systematic service process can be implemented to facilitate, mediate or assist the collaborative service. One strategy constructs mediated collaborative services that address music composition problems effectively, and even achieve the selected best partnership. *DesignStorming* adopts the mediation approach to systematic service systems, enabling the co-creation of music content.

- Performing CCSs: The e-marketplace makes it possible for the service system to perform the collaborative process of working in partnership to create music effectively.
- Evaluating the effects of music content: This work evaluates the effects of digital music content for the purpose of judging possible partnerships. A value appraisal of music content is also significant for service performance evaluation.

(3) Solution requirement

These solution requirements acquire varied responses about music content. An e-service makes it possible to reduce the costs of solving composing problems through music content descriptions. However, an SFGA incorporates and develops self-regulating control in the e-marketplace for effective relationship identification to raise partnership-matching quality in the e-marketplace.

(4) Theories

Service systems regard certain theories as underlying the development of internal methodologies within automated service exchange and service delivery. However, the inter-disciplinary theories and methodologies are subject to the development of innovative services. *DesignStorming* uses the evolution theory and optimizes the methodology (e.g., genetic algorithm and fuzzy logic) for determining the best partners. Ontology, RDF, XML, and semantic Web can also be used to describe semantic-based music content when dealing with the semantic process. J2EE, SOA, database, and service component are the system architecture.

(5) Tacit Knowledge

Tactical knowledge relies on different kinds of service sectors. With regard to music composition, tacit knowledge, music genre and music categories are derived from universal definitions used by music companies, for example, music song tags CDDB and ID3.

(6) Design Methodology

This research constructs and implements a CSS according to the above-mentioned concepts and methodologies. IS design-science concentrates on system development, design of human-computer interfaces, and architectural designs for computing and communication. The design method has its foundations in systems engineering and has evolved through various disciplinary forms such as software engineering, database and knowledgebase engineering, and collaborative technology design (Ramesh & Rao, 2005). ISM makes it possible for a prototype system to implement practically the collaborative services, whose purpose is to extend human and organizational capabilities by creating new and innovative artifacts. The design method therefore also addresses the development of the service system through building and evaluating artifacts designed to meet identified business needs. Seven guidelines for design-science in information systems research are: design as an artifact, problem relevance, design evaluation, research contributions, research rigor, design as a search, and communication of research (Havner et al. 2004). *DesignStorming* is therefore referred to as an IT artifact (i.e., prototype system) using design-science, enabling goals, problem solving strategy, solution requirements, and theories and tacit knowledge.

4.2 ISM of DesignStorming

In this study, an ISM assists in modeling and automating the cognitive process and knowledge representations as applied to the problem of music co-creation. It assists the systematic collaborative service exchange and delivery process of music creation. According to the pre-defined SSM of *DesignStorming* (Table 2), the service system can support semi-structured decisions of the cognitive process related to the selection of partners. The knowledge representation refers to the definitions of musical content, such as musical tags from an existing music database (i.e., CDDB and ID3). The service system adopts an optimization methodology (Genetic Algorithm, Fuzzy Logic), semantic-based music content process (Ontology, RDF, and XML), and system development environment (Java SE, JRE), as well as the system architecture of SOA (Fig. 2). The pre-defined SSM leads to the construction of a service system that can facilitate collaborative music content creation using three service modules, Ontology Developer,

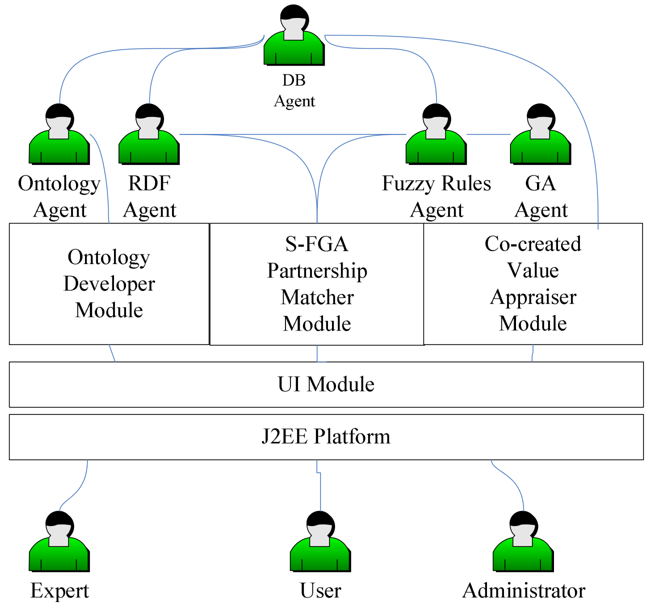

Fig. 2 The three service modules of *DesignStorming*

SFGA Partnership Matcher, and Co-Created Value Appraiser. The next section illustrates how ISM can be used to design and implement *DesignStorming*.

4.2.1 Ontology developer

DesignStorming starts with an ontology and a semantic process (RDF and XML) to define the cognitive process and knowledge representation of music content. For example, the ontology of music content can be defined by the attributes and relationships. The ontology developer is in charge of relationship recognizers and ontology transformers, assisting in defining music creation concepts. For example, tags include the genre, year, instrument, location, appraisal, citation, click, and integrated appraisal. The semantic-based fuzzy genetic algorithm (SFGA) deals with the fuzzy rules generator and partnership matcher, as well as performing partner matching according to the music content included in queries related to composing problems. Music content with certain music concepts is represented by the RDF (Resource Description Framework) triple expression as shown in Fig. 3.

The first service module in *DesignStorming*, Ontology developer, can transform ontology into RDF triple expressions of music content. It then uses XML representations for further analysis, as shown in Fig. 4.

4.2.2 SFGA partnership matcher

A scenario illustrates how *DesignStorming* can be designed and implemented for a CSS of music content. To supply the

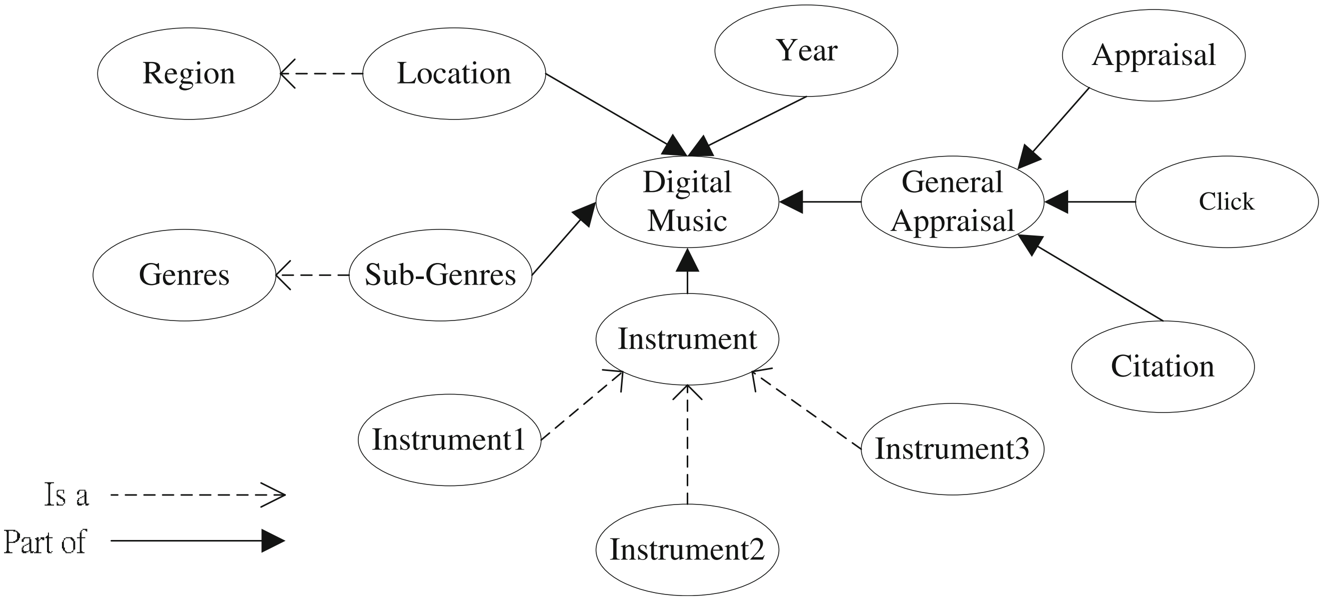

Fig. 3 Music content description represented by RDF triple expressions

inspiration that many composers need, the system provides a service that matches partners according to the music content, for example, hard rock, ancient style, play electric guitar, and Asian audience, and so on. The service module can infer music content (the right hand side of Fig. 5) from the user queries (the left hand side of Fig. 5). In order to identify semantic music content, a semantic-based fuzzy approach is applied.

ISM is an approach to modeling and automating the cognitive process and knowledge representations in CSS that enables a domain application (i.e., music content creation). *DesignStorming* is an example of a CSS that was analyzed and designed using ISM to model and automate the value co-creation processes of music content creation. The system also requires knowledge representation of musical ontology, which is used to define the concepts and attributes of music content. In addition to ontology, SFGA is used to identify the relationships between the queries and responses of other service participants; it matches partners based on optimization rules (i.e., a self-regulation control of e-marketplaces helps determine partners who can provide the best responses).

The defined attributes in ontology can be referenced in construction optimization rules that judge the requests and responses based on three matching criteria: concrete concept, diverse originality, and integrated flexibility. The decision of optimal partners can be made according to the usefulness level of the music content provided by other service participants. For instance, in order to analyze and optimize the rules, the relevance between the requests and responses of R983 and R506 can be determined, including the close location,

```xml
<?xml version="1.0"?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#" xmlns:ds="
http://www.aesl.nccu.edu.tw/rdf/">
<rdf:Description rdf:about="http://www.aesl.nccu.edu.tw/rdf/digitalMusic/983">
  <ds:year rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">1983</ds:year>
  <ds:genre rdf:resource="http://www.aesl.nccu.edu.tw/rdf/jazz/latinJazz"/>
  <ds:metagenre rdf:resource="http://www.aesl.nccu.edu.tw/rdf/jazz"/>
  <ds:area rdf:resource="http://www.aesl.nccu.edu.tw/rdf/eastAsia/taiwan"/>
  <ds:metaarea rdf:resource="http://www.aesl.nccu.edu.tw/rdf/eastAsia"/>
  <ds:instument>
    <rdf:Bag>
      <rdf:li rdf:resource="http://www.aesl.nccu.edu.tw/rdf/instument/piano"/>
    </rdf:Bag>
  </ds:instument>
  <ds:appraisal>
    <ds:average rdf:datatype="http://www.w3.org/2001/XMLSchema#decimal">7.3</ds:average>
    <ds:publicscore rdf:datatype="http://www.w3.org/2001/XMLSchema#decimal">6.5</ds:publicscore>
    <ds:click rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">98</ds:click>
    <ds:citation rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">8</ds:citation>
  </ds:appraisal>
</rdf:Description>
</rdf:RDF>
```

Fig. 4 XML representations of music creations

1. genre is hard rock song	*1. resembling genre: hard rock*
2.ancient style	*2. resembling year:1950*
3.play electric guitar	*3. resembling instrument: electronic guitar*
4.forAsian audience	*4. resembling location: Asian audience*

Fig. 5 Example of music content composing requests

different category, different instrument, invariable generation change, and high appraisal (Table 3). The example illustrates a query of a user (as customer) who proposes the request R506 about music content creation and receives a high concretion level for concept from a service participant (as provider) who provided the response R983. Another example is defined as 'IF Location = far, Genre = similar, Year = changeable, Appraisal = good THEN Diverse Originality = high.'

The SFGA is used to match the fuzzy rules and improve the determination of optimized partners. The fuzzy rules can be evaluated according to three criteria: coverage, accuracy, and concision (Yuan & Zhuang, 1996). Coverage represents how many data instances are covered by all fuzzy rules r;

$$mA_k(r,u) = \begin{cases} 1, if\,¡@S(A_k) = nothing \\ \underset{j}{Max}(Min(s(T_j^k), \mu_{t_j^k}(u))), otherwise \end{cases}$$ where

μ is a data instance (u is population of data instances), $s(A_k)$ is the k^{th} attribute of rule r, $mA_k(r,u)$ denotes a quantity indicating how the data instance μ fits with the condition of rule r (when considering only attribute k) before computing the coverage of rule r (i.e., probability of data instances condition matched by rule r). T_j^k represents the j^{th} fuzzy term of the k^{th} attribute. $mA_k(r,u)$ will be 1 (indicating u is a satisfied instance) if $s(A_k)$ is null, otherwise, $mA_k(r,u)$ will be the min-max membership value associated with the k^{th} attribute between rule r and data instance u.

Users' responses can be considered to be the parts of music content creation (e.g., 6826 etc.) The three evaluation criteria are creativity, integration, and concretion, and are used to determine the fuzzy rules and select the rules as candidates after running 20th generations of the genetic algorithm (GA) as follows:

IF Location = near AND Genre = similar OR different Year′s variation = constant AND Appraisal = medium ORhigh THEN Concretion = High
IF Genre = similar AND Year′s variation = changeable AND Instrument = similar THEN Creativity = High
IF Instrument = Similar AND Year′s variation = changeable AND Genre = similar OR alike THEN Integration = High

The system can describe the contexts of music content as conditional parts of fuzzy rules:

1. Creation location: distance D = {far, near, close}
2. Creation genre: type T = {different, similar, same}
3. Creation year: change R = {constant, gradual_change, radical_change}
4. Creation instrument: category C = {different, mixed, repeated}
5. Creation appraisal score: level L = {good, average, inferior}

Describing fuzzy rules combines both conditions and results encoded by binary (0/1). For example, {1000101001110111111001111} is a combination of fuzzy rules that comply with both conditions and results including {far→100, similar→010, radical change→100, NULL→111, average OR good→011} and {NULL→111, creativity→001, NULL→111} respectively. Above, the fuzzy rule is of high creativity but without integration and concretion due to far location, similar genre, radical change for year, unspecified instruments, and appraisal score being both good and average. The SFGA, however, is used to address these rules of context in music content according to the levels of integrity, accuracy, and conciseness. Evaluating the semantic fuzzy rules improves the quality of the selections of the optimized

Table 3 Example of analyzing the optimized rules (Wu, 2007)

	Request R506	Response R983	Relationship
Location/resembling location	Asia	Asia	Location = close
Area/resembling area	East Asia	East Asia	
Genre /resembling genre	Hard Rock	Latin Jazz	Category = different
Category /resembling category	Rock	Jazz	
Instrument/resembling instrument	Electronic guitar	Piano	Instrument = different
Year /resembling year	1950	1983	Generation change = invariable
Appraisal score	N/A	7.3	Appraisal = high

partners matched by SFGA. In other words, the system responds to users who pose their problems concerning the creation of music content and make selection decisions among the matched partners. For example, creation 6826 has a high level of concretion and of creativity. Creation 6828 does not fit with any condition (Fig. 6).

4.2.3 Co-created value appraiser

DesignStorming can be viewed as a marketplace where requests concerning music content creations are shown and opinions are exchanged. In addition to the matching-partners component, the system provides bidding, purchasing, and appraisal functions for the music content selections, using the Value Appraiser service component.

According to the descriptions of the service components of Ontology Developer, SFGA Partnership Matcher, and co-created Value Appraiser, we can enable semi-automated value co-creation through the collaborative service process. The system allows users (collaborators) successive service exchanges to mediate the partner matching process. Requested music content production can be diversified and facilitated from the partner's responses in the collaborative service process. Users can subsequently listen to music content creations from other user responses. Listing the music content creations received in response to queries allows users to bid prior to purchasing in the e-marketplace (Fig. 7).

Additionally, *DesignStorming* can be validated by a specific evaluation model to assess and testify to service productivity. The model is called E-QUAL (Tung & Yuan, 2007). In general, a service output ($\overline{R}$) is divided by a service cost (L) to obtain service productivity. As a CSS is a semi-automated value co-creation service system, its service participants need more interactive and communicative service exchanges in the service process. However, the holistic service outcome ($\sum PR = \sum e^{[\beta^T x]}$) is accumulated by each service exchange or each collaborative service outcome, PR. The equation for assessing each collaborative service outcome (output) is $e^{[\beta^t x]}$ where β refers to the factor's weight, and x refers to the specified factor that can influence service outcome. In terms of *DesignStorming*, the system defines the three factors: diverse originality (PF_1), integrated flexibility (PF_2), and diversity (PF_3), all of which can influence the collaborative service outcome in the service process. As a result, PF_1, PF_2, and PF_3 are the three factors X_n and the three default weights β_n to measure $e^{[\beta^T x]}$ and then measure each collaborative service outcome. β refers to the corresponding weight of each factor *(X_n),* which depends on the level of significance among the factors. Each collaborative service outcome $e^{[\beta^T x]}$ can be viewed as an interactive fitness function to represent the part of service performances (i.e., 2.61, 1.70, 1.07, 1.46, and 1.82). A holistic service productivity is $\overline{R} = \sum e^{[\beta^T x]} = 8.66$. IF $\sum PR = \sum e^{[\beta^T x]}$ is divided by a service cost L, it results in the number of times of interactions in the service process. In this case, service productivity (i.e., 1.73) can be estimated by the accumulated collaborative service outcomes of five music content responses when a query submits a request $\frac{\sum e^{[\beta^T x]}}{L}$ (Table 4). The five collaborative service outcomes and the holistic service productivity can be seen in Table 4 and Fig. 8. According to the results of Table 4, Response music content 1 is the best service outcome among the five responses.

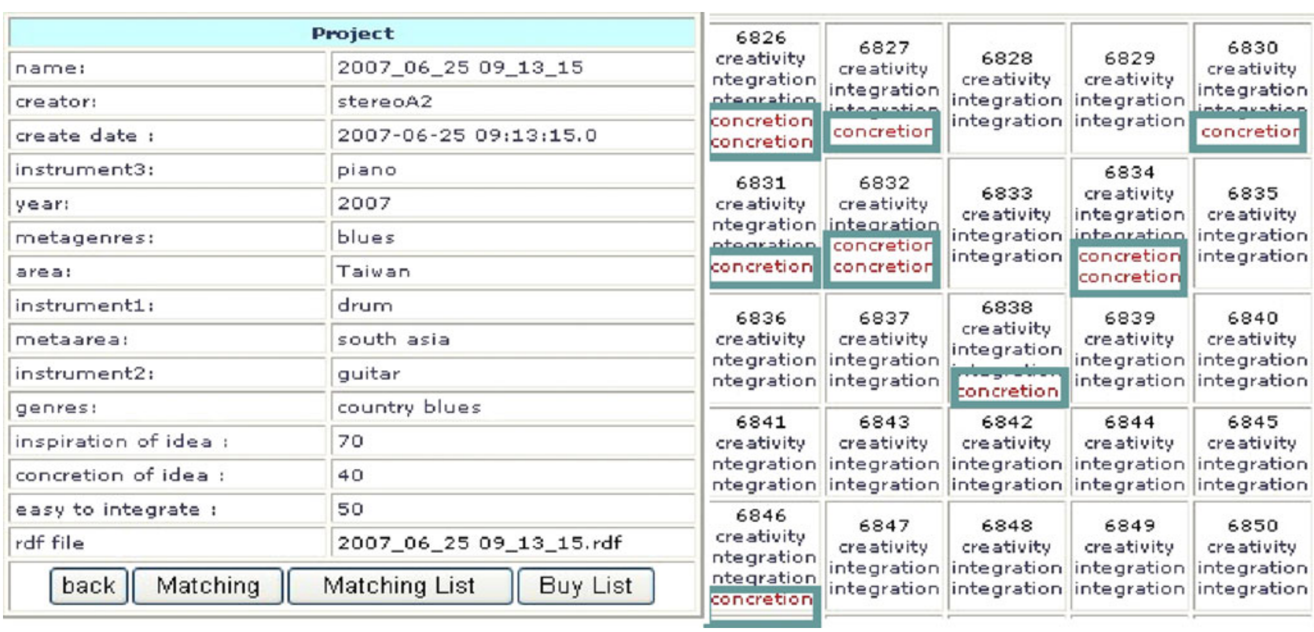

Fig. 6 Automating partner matching using the three conditions

Fig. 7 Music content creation after partner matching

Figure 8 shows the service outcomes compared with the threshold 1.0. The research uses some simulation data to test and verify the service productivity of *DesignStorming*.

5 Implications and discussion

The service sector is becoming increasingly significant in the economies of many countries, in particular developed countries, where the services industries account for a dominant percentage of economic activity. SSME paints the picture of systematic service innovation in order to propel the service sector into competition. Collaborative service systems can lead to innovation in the service industry. To this end, both SSM and ISM are capable of supporting systematic service innovation and supplying semi-automated value co-creation. This paper proposes a new approach to CSS analysis, design, and development. SSM focuses on the attributes of designing CSS. ISM is a design for modeling and automating the cognitive process and knowledge representations applied to the service system design problem. *DesignStorming* then demonstrates a CSS design-mediated collaborative technology and optimization algorithm (GA) based on SSM and ISM. The system supplies an intelligent service system design using state-of-the-art technologies, which mediates the semi-automated value co-creation and collaborative service processes, including RDF, ontology, fuzzy logic, genetic algorithm, and so on.

Table 4 Testing the service productivity of CSS (*DesignStorming*)

Response music content	PF_1	PF_2	PF_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	$e^{0.60}=1.82$

$$\text{Service Productivity} = \frac{\sum e^{[\beta^T x]}}{L} = 8.66/5 = 1.73$$

From the applications perspective, *DesignStorming* is a CSS application for composing music. ISM helps the service system construction of collaborative music content and self-regulating controls, enabling the development of SFGA to address these needs. As a result of collaborative intelligence emerging from the collaborative service process, *DesignStorming* provides a platform for systematic partner matching for composing music. In terms of the aspect of communication, the users can acquire more diversified music content from other users' inspirations.

SSM and ISM can be utilized and applied to not only the CSS of music content creation but also other types of CSS, for example, interior design, mobile phone design, and so on. (Tung & Yuan, 2008). Besides the design fields, SSM and ISM can also be utilized and applied to other fields, for example, product/service searching, recommendation and customization, as well as various matching services. That is, the design method is particularly appropriate for collaboration-oriented services that can be delivered through

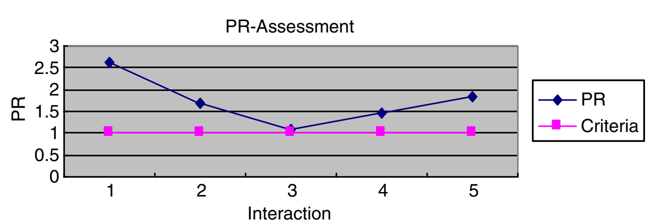

Fig. 8 Each collaborative service outcome compared with threshold

CSS enabling automated value co-creation. As long as an online service needs more interaction and communication in its service process, SSM and ISM can be used to enable systematic service innovation and semi-automated value co-creation for its service process. For instance, customization services can provide a platform to allow service providers to understand the customer's detailed requirements through better interaction and communication means to make delivery decision of service provision.

6 Conclusion

This research utilizes an IT artifact design of design science research to demonstrate a collaborative service systems (CSS) modeling and developing. Simple service machine (SSM) provides the six salient characteristic elements. Intelligent service machine (ISM) conducts modeling and automating the cognitive process and knowledge representation applied to the relevant design problems. *DesignStorming* is a demonstration of CSS application that allows users to communicate and solve the problems involved in composing music content. The CSS can evidence what/how a new approach (SSM and ISM) to supporting systematic service innovation and semi-automated value co-creation of collaborative services process. *DesignStormin*g consists of three service components: 1) Ontology Developer, 2) SFGA Partnership Matcher, and 3) Co-created Value Appraiser. The three components adopt collaborative technology, optimization methodology (SFGA), and semantic processes (Ontology, RDF, XML, and semantic Web) featuring systematic coordination for the collaborative creation of music content. That is, this research introduces SSM and ISM to design and develop *DesignStormin*g as a demonstration and verification of IT artifacts. Although SSM and ISM are an aid to CSS engineering, the demonstration of *DesignStorming* is limited to music content creation. When another service industry requires such a CSS, a variety of domain-dependent problems need to be taken into consideration. In addition, future works can also explore forms of intelligent design methods and other types of CSS applications for further demonstration of the utility of SSM and ISM.

References

Allen, G. S., Mugge, P., & Wolff, M. F. (2006). Services science to be taught at NC state. *Research Technology Management, 49*(6), 6–7.

Bardhan, I. R., Demirkan, H., Kannan, P. K., Kauffman, R. J., & Sougstad, R. (2010). An interdisciplinary perspective on IT services management and service science. *Journal of Management Information Systems, 26*(4), 13–64.

Beatson, A., Lee, N., & Coote, L. V. (2007). Self-service technology and the service encounter. *Service Industries Journal, 27*(1), 75–89.

Benaroch, M., Dai, Q., & Kauffman, R. J. (2010). Should we go our own way? Back sourcing flexibility in IT services contracts. *Journal of Management Information Systems, 26*(4), 317–358.

Bijker, W. E. (1995). *Of bicycles, bakelites, and bulbs: Toward a theory of sociotechnical change*. Cambridge, MA: MIT Press.

Bitner, M. J., & Brown, S. W. (2006). The evolution and discovery of services science in business schools. *Communications of the ACM, 49*(7), 73–78.

Boongasame, L., & Daneshgar, F. (2011). A collaborative platform for buyer coalition: Introducing the awareness-based buyer coalition (ABC) system, *Information Systems Frontiers*, Online First, June.

Bostrom, R., & Heinen, J. S. (1977). MIS problems and failures: A socio-technical perspective PART I: The causes. *MIS Quarterly, 1*(3), 17–30.

Caswell, N. S., Nikolaou, C., Sairamesh, J., Bitsaki, M., Koutras, G. D., & Lacovidis, G. (2008). Estimating value in service systems: A case study of a repair service system. *IBM Systems Journal, 47*(1), 87–100.

Cox, D. E., & Kreger, H. (2005). Management of the service-oriented architecture life cycle. *IBM Systems Journal, 44*(4), 709–726.

Demirkan, H., & Goul, M. (2008). Process and services fusion impact assessment: SSME findings from industry collaboration and the need for competency centers. In B. Hefley & W. Murphy (Eds.), *Service science, management and engineering: Education for the 21st Century* (pp. 257–262). New York: Springer.

Demirkan, H., Kauffman, R. J., Vayghan, J., Fill, H. G., Karagiannis, D., & Maglio, P. P. (2008). Service-oriented technology and management: Perspectives on research and practice for the coming decade. *Electronic Commerce Research and Applications, 7*(4), 356–376.

Etzion, O., Fisher, A., & Wasserkrug, S. (2005). e-CLV: A modeling approach for customer lifetime evaluation in e-commerce domains, with an Application and case study for online auction. *Information Systems Frontiers, 7*(4–5), 421–434.

Fitzsimmons, J. A., & Fitzsimmons, M. J. (2004). *Service management: Operations, strategy, and information technology* (3rd ed.). N.Y: McGraw-Hill.

Frei, F. X. (2008). The four things a service business must get right. *Harvard Business Review, 86*(4), 70–80.

Havner, A. R., March, S. T., Park, J., & Ram, S. (2004). Design science in information systems research. *MIS Quarterly, 28*(1), 75–105.

Imaz, M., & Benyon, D. (2007). Designing with Blends Conceptual Foundations of Human-Computer Interaction and Software Engineering, MIT Press.

Lamb, R., & Kling, R. (2003). Reconceptualizing users as social actors in information systems research. *MIS Quarterly, 27*(2), 197–235.

Maglio, P. P., Srinivasan, S., Kreulen, J. T., & Spohrer, J. (2006). Service systems, service scientists, SSME, and innovation. *Communications of the ACM, 49*(7), 81–85.

Marglio, P. P., & Spohrer, J. (2008). Fundamentals of service science. *Journal of the Academy of Marketing Science, 36*(1), 18–20.

Oh, L. B., & Teo, H. H. (2010). Consumer value Co-creation in a Hybrid commerce service-delivery system. *International Journal of Electronic Commerce, 14*(3), 35–62.

Payne, A., Storbacka, K., & Frow, P. (2008). Managing the co-creation of value. *Journal of the Academy of Marketing Science, 36*(1), 83–96.

Ramesh, R., & Rao, H. R. (2005). Forward design science and information systems. *Information Systems Frontiers, 7*(3), 215.

Ray, P., Shahrestani, S. A., & Daneshgar, F. (2005). The role of fuzzy awareness modelling in cooperative management. *Information Systems Frontiers, 7*(3), 299–316.

Sheehan, T. N., & Stabell, B. C. (2006). Reputation and value creation in search shops. *Service Industries Journal, 26*(6), 597–613.

Spohrer, J., Maglio, P.P., Bailey, J., & Gruhl, D. (2007). Steps toward a science of service systems. *IEEE Computer,* Jan, 71–76.

Spohrer, J., & Maglio, P. P. (2008). The emergence of service science: Toward systematic service innovations to accelerate co-creation of value. *Production and Operations Management, 17*(3), 238–246.

Tien, J., & Berg, D. A. (2003). Case for service systems engineering. *Journal of Systems Science and Systems Engineering, 12*(1), 13–38.

Tung, W. F., & Yuan, S. T. (2007). *Optimization of collaborative service systems using an experience evaluation model*. Salt Lake City, USA: Proceedings of IEEE International Conference on Services Computing.

Tung, W. F., & Yuan, S. T. (2008). A service design framework for value co-production: Insight from mutualism perspective. *Kybernetes: International Journal of Systems, Cybernetics and Management Science, 37*(2), 226–240.

Vargo, S. L., & Lusch, R. F. (2008). Service-dominant logic: Continuing the evolution. *Journal of Retailing, 61*, 78–103.

Wu, Y. C. (2007). *Semantic-based digital content design in collaborative service marketplace*. Taiwan: Master Thesis, Dept of MIS, National Chengchi University.

Yuan, Y., & Zhuang, H. A. (1996). Genetic algorithm for generating fuzzy classification rules. *Fuzzy Sets and Systems, 84*(1), 1–19.

Zeithaml, V. A., Berry, A. L., & Parasuraman, A. (1993). The nature and determinants of customer expectations of service. *Academy of Marketing Science Journal, 21*(1), 1–12.

Zeithaml, V. A., Bitner, M. J., & Gremler, D. D. (2009). *Services marketing: Integrating customer focus across the firm* (5th ed.). New York: McGraw-Hill.

Zhao, J. L., Tanniru, M., & Zhang, L. J. (2007). Services computing as the foundation of enterprise agility: Overview of recent advances and introduction to the special issue. *Information Systems Frontiers, 9*(1), 1–8.

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