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Regular Paper

Analysis and Design Methodology for Recognizing Opportunities and Difficulties for Product-based Services

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Recently, manufacturing companies have been moving into product-based service businesses in addition to providing the products themselves. However, it is not easy for engineers in manufacturing companies to create new service businesses because their skills, mental models, design processes, and organization are optimized for product design and not for service design. In order to design product-based services more effectively and efficiently, systematic design methodologies suitable for the service businesses are necessary. Based on the case analysis of more than 40 Japan-US product-based services, this paper introduces a product-based service design methodology called DFACE-SI. DFACE-SI consists of five steps from service concept generation to service business plan description. Characteristic features of DFACE-SI include visualization tools to facilitate stakeholders' recognition of new opportunities and difficulties of the target product-based service. Opportunities and difficulties are recognized using the customer contact expansion model and the failure mode checklist, respectively, which are extracted from the service case analysis. We apply DFACE-SI to a pilot project and illustrate its effectiveness.

1. Introduction

In light of the ongoing transformation from a traditional industrial society to a knowledge-based society, many manufacturing companies have tended to integrate services into their core product offerings. Van Looy, et al. [1] identified two reasons why companies are moving into service businesses. One is to meet customer's requirements. The customer requires a value creating process (e.g., driving) with a product, and does not require the product itself (e.g., a car). The other is to differentiate products by product-based services. Services can provide continuing value and revenue through a life cycle of products (e.g., proactive maintenance by remote monitoring).

However, when engineers who design products try to design services, they encounter difficulties. This is because their skills, mental models, design processes, and organization are built up and optimized for product design and not for service design. They need systematic design methodologies for designing product-based services more effectively and efficiently. We have developed a service design methodology DFACE-SI.

DFACE [2] is a design methodology used widely in Toshiba Corporation based on Design for Six Sigma (DFSS), and DFACE-SI is a specialized version of DFACE for Service Innovation (SI). DFACE-SI consists of five steps from service concept generation to service business plan description. The main purpose of DFACE-SI is to facilitate stakeholders' recognition of new opportunities and difficulties of a target service. To achieve this, DFACE-SI provides charts and tools for finding opportunities (concept generation) and difficulties (risk analysis). DFACE-SI also provides service function templates, service design patterns and failure mode checklists extracted from the service case analysis, which can be of assistance in designing and evaluating service concepts and schemes.

After clarifying opportunities and difficulties of service businesses in Section 2, we introduce the DFACE-SI concept, procedure, and tools in Section 3. Then, Section 4 discusses the application of DFACE-SI to a pilot project (service planning for a digital video camera) and illustrates its procedure in detail. We clarify qualitative effectiveness and the strong points of DFACE-SI as compared with related works in Section 5 and Section 6, which is followed by the conclusion in Section 7.

2. Opportunities and Difficulties of Service Businesses for Manufacturers

2.1 Opportunities

Some excellent manufacturing companies such as GE have been expanding service businesses based on their core products. As much of the literature on management suggests, there are many opportunities for manufacturing industry,

†1 Toshiba Corporation
†2 Stanford University

which has been experiencing severe global price competition, to engage in service businesses [3),4)].

However, it is unclear how manufacturing companies can exploit these opportunities. If there are typical transition patterns (tried and true tactics) from product businesses to service businesses, these will help manufacturing companies develop strategy for service businesses. We have been seeking typical transition patterns from the viewpoint of customer contact point expansion based on 40 case studies [⋆1] of successful practices of service businesses in manufacturing companies in Japan and the U.S.

A product-based service is here defined as a value co-creation process with a product through collaboration between a customer and a manufacturer, where the customer-manufacturer contact point plays an important role. The original contact point is buying and selling of products. Our model (Customer Contact Expansion Model) [6)] shows the following three expansions (adjustment expansion, commitment expansion, and territory expansion) from the original contact point of product-based services, which are extracted from the 40 case studies. These expansions can provide additional service values (better quality, reassurance, and convenience) to the products.

Adjustment Expansion (Better Quality): Adjust products to the specific needs and usage of each customer to maximize their quality and functions (e.g., maintenance, customizing, and consulting services)

Commitment Expansion (Reassurance): Raise the commitment rate for taking customer's risk (e.g., rental, leasing, and outsourcing services)

Territory Expansion (Convenience): Offer additional functions with products to realize what the customer wants to achieve, or provide a service platform for third parties to offer these functions (e.g., one-stop solution, service platform provider).

Furthermore, we show that the 40 best practices of manufacturers' service businesses can be characterized by these 3 expansions and be classified into 9 types (**Table 1**). In the following sections, we break the 3 expansions down into 8 service function templates (Table 3). Our model can provide concrete templates for finding opportunities for product-based service businesses.

2.2 Difficulties

Even if opportunities can be recognized, it is not easy for manufacturing companies to successfully manage the transition from product businesses to services. Calthrop and Baveja [7)] showed that only 21 percent of companies have achieved success with their service strategies. We analyzed the difficulties of transition from products businesses to service businesses through case studies and interviews in Toshiba. **Figure 1** is a cause-effect diagram (fishbone diagram) indicating business model difficulties and organizational difficulties. Whereas the business model difficulties (critical mass, social acceptability, pricing, etc.) are common to all services, the organizational difficulties are specific to manufacturing companies. The major organizational difficulties include the following items:

- Structural gaps between product and service businesses:
  There are big process gaps between product businesses (outright selling) and service businesses (interactive and continuous value creation). Service businesses require organizational transformation for interactive and continuous services operation. However, even if the service concept is good, it is difficult to realize the organizational transformation in a manufacturing company.
- Conflict among stakeholders:
  Organizational conflicts among stakeholders become often obvious including difficult revenue share and less synergy between product and service businesses.
- Poor understanding & decision of service businesses:
  Most of manufacturing companies have insufficient experience to manage service businesses. Poor understanding leads people to unproductive discussion and poor decision making.

It is important for stakeholders to identify and recognize these difficulties at the planning stage. Therefore, DFACE-SI supports the task (risk analysis using Project FMEA) by providing failure mode checklists derived from the cause-effect diagram (See Table 5).

⋆1 This case study project was led by the JAIST MOT team (leader: Prof. Akio Kameoka), which is supported by the New Energy and Industrial Technology Development Organization (NEDO) of Japan [5)].

Table 1 9 Types derived from 40 cases in the customer contact expansion model[6].

Type	A	C	T	Num	Product-based Services
1	M	S	S	1	Elevator maintenance
2	S	M	S	5	Electronic money by RFID, document outsourcing, PDP information service, PFI, railway information service
3	S	S	M	6	Ringing melody service, DVD content recommendation, telematics, automatic ticket gate information service, music download, electricity usage monitoring service
4	M	S	-	9	Maintenance services (exposure equipment, security system, ATM, parking facility, water and sewerage system, gas turbine, physical distribution system), coating system management, POS system support
5	S	M	-	5	ESCO, residential property maintenance, coating system outsourcing, rental washing machine, aircraft engine leasing
6	S	-	M	6	Housing improvement service, PDP-based meeting support system, information system by construction company, maintenance portal site, mobile phone solution, management consulting by manufacturer
7	M	-	-	4	Cement solution, chemical goods maintenance, seismic diagnosis, aircraft information service
8	-	M	-	2	Financial service, rental PC
9	-	-	M	2	One-stop mobile phone solution, industrial gas distribution system

(A: Adjustment expansion, C: Commitment expansion, T: Territory expansion, Num: Number of cases, M: main feature, S: subsidiary feature)

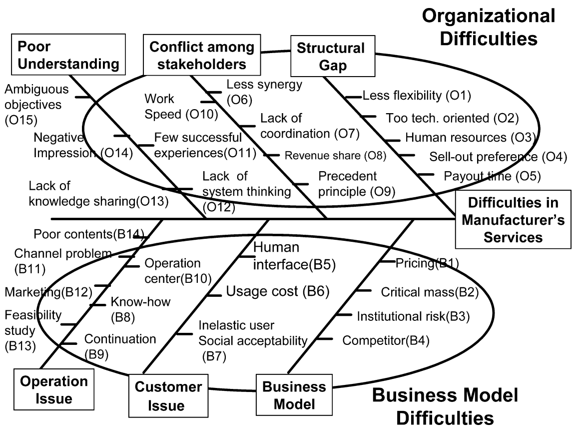


Fig. 1 Cause-effect diagram for identifying difficulties.

3. DFACE-SI

3.1 Basic Concept

The main purpose of DFACE-SI is to establish shared recognition of opportunities and difficulties of a product-based service among stakeholders. Although there is no magic wand for designing a successful service business, we think that the shared recognition among stakeholders is a prerequisite for successfully designing a service business. In order to support the recognition of opportunities and difficulties, DFACE-SI provides design tools and design charts with service function templates, service design patterns and failure mode checklists, which are extracted from the service case analysis (explanation of tools and charts will be in Section 3.3 and **Table 2**). The service case analysis is based on the external 40 best practices[5] and several in-house cases.

DFACE-SI has three main phases (**Fig. 2**):

(1) Service concept generation using idea generation support tools (Customer Contact Expansion Model, Scenario Graph, and Value Graph) for recog-

Table 2 Charts and tools used in DFACE-SI.

Chart/Tool	Explanation	Used in
Customer Contact Expansion Model*	Service analysis model for product-based services using 3 expansion and 8 service functions.	Step1
Service Function Template*	Typical service functions extracted from case analysis based on the customer contact expansion model.	Step1
Scenario Graph**	Idea generation tool that enumerates service scenes with the target product using association keys (WHO, WHEN, WHERE).	Step1
Value Graph**	Idea generation tool that enumerates service concepts with the target product using association keys (WHAT, HOW). Here, service function templates are used as association keys of HOW.	Step1
Strategic Canvas***	Service concept selection tool based on visual comparison of value proposition.	Step1
QFD*** (Quality Function Deployment)	Service concept selection tool based on weighted averaging.	Step1
Entity/Activity Chart*	Design chart describing structure model of the service that specifies structural relations between entities and activities.	Step2
CVCA** (Customer Value Chain Analysis)	Design chart describing flow model of the service that specifies value flows among entities.	Step2
Scenario Chart*	Design chart describing behavior model of the service that specifies sequences of activities.	Step2
Service Design Pattern*	Typical entity/activity charts extracted from the case analysis.	Step2
Failure Mode Checklist*	Typical failure mode extracted from the case analysis.	Step4
Project FMEA** (Failure Mode and Effect Analysis)	FMEA tool for recognizing risks in service design and transformation process.	Step4

*: DFACE-SI original tool, **: DFACE/DfM tool, ***: existing tool

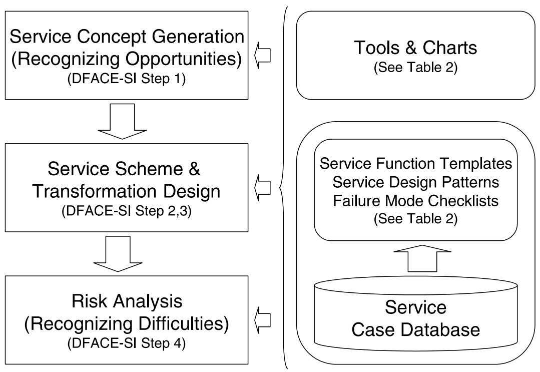


Fig. 2 Basic concept of DFACE-SI.

nizing opportunities. Service function templates of Customer Contact Expansion Model are used for generating service functions that configure the service concept.

(2) Service scheme and transformation design using design charts (Entity/Activity Chart, CVCA, and Scenario Chart) and service design patterns.

(3) Risk analysis using failure mode checklists and Project FMEA for recognizing difficulties.

3.2 Procedure

An input of DFACE-SI is the target product information and an output is a product-based service business plan. DFACE-SI consists of the following five steps (**Fig. 3**). An illustrative explanation with examples is provided in Section 4.

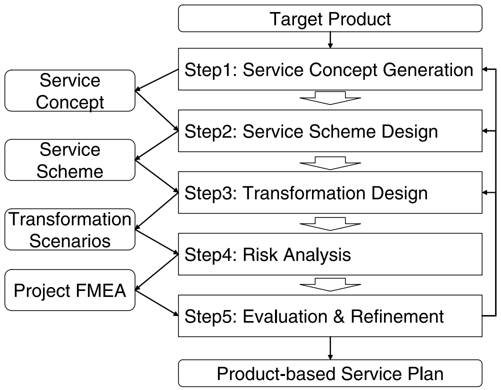


Fig. 3 Procedure of DFACE-SI.

Step1: Service concept generation

This service concept generation step starts from the target product. Using Scenario Graph and Value Graph, the designer specifies 5W (WHO, WHEN, WHERE, WHY, and WHAT) features for a product-based service. Then, he finds 1H (HOW) features (EM: Engineering Metrics = functions) using the Customer Contact Expansion Model, which suggests eight directions of possible service functions. Several suites of service functions form candidate final service concepts. The final concept is selected using concept selection tools (Strategy Canvas [10] and QFD [11]).

Step2: Service scheme design

A service scheme shows a business model, procedure, and organization for realizing the service concept. It is described using several charts (Entity/Activity Chart, CVCA, and Scenario Chart). Here, the designer can describe the scheme by modifying service design patterns extracted from the case database by matching attribute patterns. Typical design patterns include maintenance service (adjustment expansion), rental service (commitment expansion), and content distribution and updating service (territory expansion), which appear in Table 1 (types 7, 8, 9). Most services consist of a combination of patterns (types 1–6). In addition, a rough earnings model is calculated in the traditional way (Discounted Cash Flow Method, etc.).

Step3: Transformation design

For implementing the service scheme, it is necessary to transform from a current organization (As-Is) to a target organization (To-Be). Examples of the organizational transformation include establishment of a customer contact center, development of a service channel and an agency, and training of service managers and operators. The designer designs these organizational transformation scenarios.

Step4: Risk analysis

Project FMEA (Failure Modes and Effects Analysis) is applied to a service scheme and organizational transformation scenarios. Here, likely failure modes can be derived from the failure mode checklists.

Step5: Evaluation and Refinement

The designer evaluates the rough earnings model and risks. If he finds problems that need to be solved, he goes back to previous steps in order to improve service concepts, service schemes, and transformation scenarios. Finally he describes a final plan (a service concept, a service scheme, transformation scenarios, and Project FMEA) with detailed explanation, and then a decision-maker decides GO or NOGO for the plan.

3.3 Tools

In the five steps of DFACE-SI, we use several tools and charts: Customer Contact Expansion Model, Scenario Graph [8], Value Graph, Entity/Activity Chart, CVCA, Scenario Chart, Project FMEA, service function templates, service design patterns, and failure mode checklists. Table 2 shows brief explanation of these tools and charts. Scenario Graph, Value Graph, CVCA, and Project FMEA are introduced in Stanford University Course ME317: Design for Manufacturability (DfM) [9]. In this section, we explain how Customer Contact Expansion Model (service function templates) and Entity/Activity Chart are used for service concept generation and for service scheme design, respectively. These tools are original and play important roles in DFACE-SI. Customer Contact Expansion Model provides 3 expansion axes. We can retract the following 8 elemental service function templates from these axes (**Table 3**). The designer can create actual service functions (EM: engineering metrics) by associating WHAT items (CR: customer requirements) of Value Graph with these 8 elementary function

Table 3 8 elementary service function templates in customer contact expansion model.

Expansion Type	Elementary Function	Explanation
Adjustment Expansion	Consulting	Consulting services to teach customers how they can make better use of the product
	Customizing	Customizing services to improve the product so that customers can make better use of it.
	Downtime and Risk Reduction	Maintenance services to reduce downtime and related risks by using monitoring information of the product.
Commitment Expansion	Financial Risk Reduction	Risk reduction services to take over financial risks (e.g., repair cost and investment risk) in place of customers.
	Social Risk Reduction	Risk reduction services to take over social risks (social responsibility) in place of customers.
	Operational Efficiency	Operation services to operate the product more efficiently in place of customers.
Territory Expansion	Seamless Services	Related services necessary to solve customers' problems with the product, which are seamlessly provided.
	Rich Content	Content delivery and updating services by a platform connected to the products, where the content is processed in the product (e.g., content recommendation).

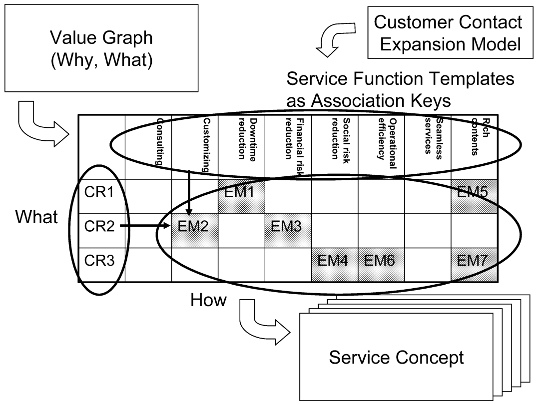


Fig. 4 Service function creation using customer contact expansion model.

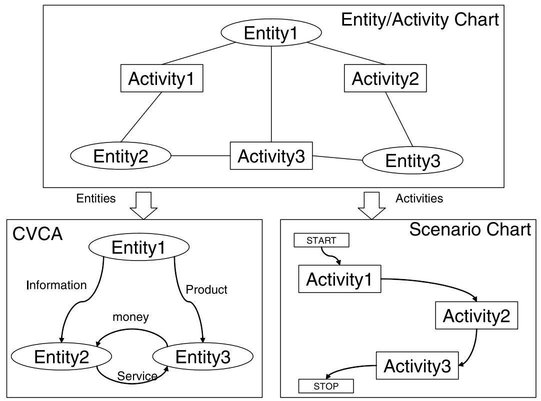


Fig. 5 Three charts representing service scheme.

templates as association keys (**Fig. 4**).

A service design scheme consists of a structure model (Entity/Activity Chart), a flow model (CVCA), and a behavior model (Scenario Chart). Entity/Activity Chart is an undirected bipartite graph. Entity nodes represent products, users, organizations, and information and activity nodes represent a function of the entities. An edge between an entity and an activity represents that the activity is executed with the linked entities. CVCA shows value flows (money, information, product, claim, etc.) among entities and Scenario Chart shows an execution sequence of activities (control flow). CVCA and Scenario Chart are derived from Entity/Activity Chart (**Fig. 5**).

Molecular model and service blueprint model are widely used in service modeling [14], which correspond to a flow model and a behavior model. It should be noted that a structure model (Entity/Activity Chart) provides a good starting point from which other models can be smoothly derived. Furthermore, typical design patterns are prepared by means of Entity/Activity Chart in DFACE-SI.

4. Service Business for Digital Video Camera

According to the five steps of DFACE-SI, we will make a service business plan for the purpose of illustration. Here, the target product is a digital video camera (DVC), which has a hard disk and is connectable with a PC and the Internet.

Step 1: Service concept generation

The designer enumerates several target service scenes using Scenario Graph from three viewpoints (WHO, WHERE, and WHEN), and selects one of them. In this case, a scene in which a user records at sightseeing spots and enjoys memories at home is selected (**Fig. 6**).

After considering the essence of the target service from two viewpoints (WHY and WHAT), the designer identifies key functions (HOW) to realize them using Customer Contact Expansion Model. In this case, several service functions (EM: Engineering Metrics) are recognized in **Fig. 7** and **Table 4** (camera rental, camera shake adjustment, video editing software, etc.) that realize Customer Requirements (CR). For example, a function "camera shake adjustment" is created at an intersection of "recording beautiful scene" and "customizing" as shown in Table 4 where row items are derived from Customer Requirement in Value Graph, and column items are 8 elementary function templates as association keys.

A final service concept (rental digital video camera service) is selected using Strategy Canvas [10] (**Fig. 8**). The final service concept consists of three functions:

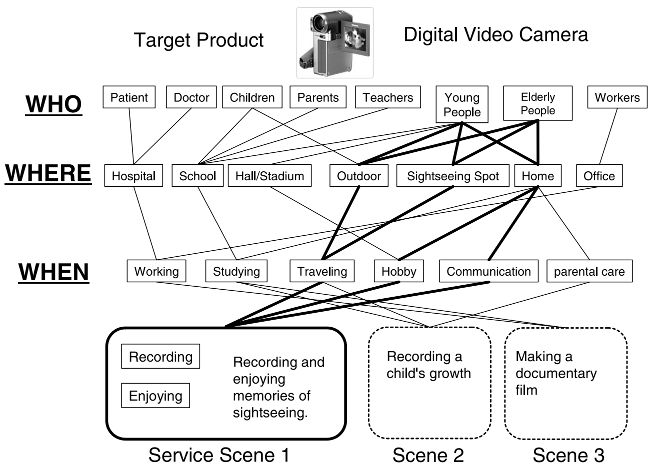


Fig. 6 Scenario graph for digital video camera.

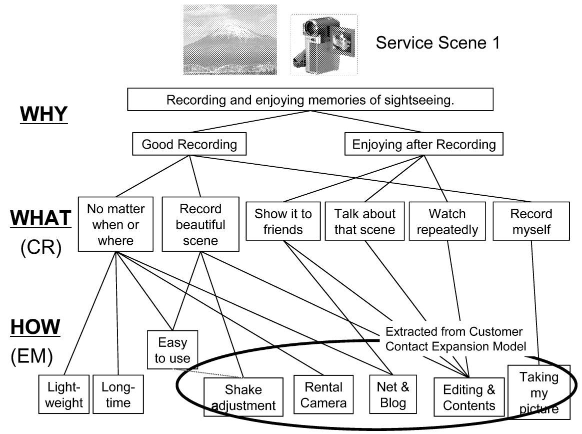


Fig. 7 Value graph for DVC rental.

Table 4 Customer contact expansion model for DVC rental.

	Adjustment Expansion			Commitment Expansion			Territory Expansion	
	Customizing	Downtime Reduction	Consulting	Financial Risk Reduction	Social Risk Reduction	Operational Efficiency	Seamless Services	Rich Contents
No matter when or where	N/A	N/A	N/A	Camera rental	N/A	N/A	Download from net	N/A
Record beautiful scene	Camera shake adjustment	N/A	N/A	N/A	N/A	Support of editing	Supporting to edit	Supporting to edit
Show it to friends	N/A	N/A	N/A	N/A	N/A	N/A	Sharing over Internet	Sightseeing contents
Talk about that scene	N/A	N/A	N/A	N/A	N/A	N/A	Connecting to Blog	Sightseeing contents
Watch repeatedly	N/A	N/A	N/A	N/A	N/A	N/A	N/A	New additional contents
Record myself	N/A	N/A	N/A	N/A	N/A	Taking my picture	N/A	N/A

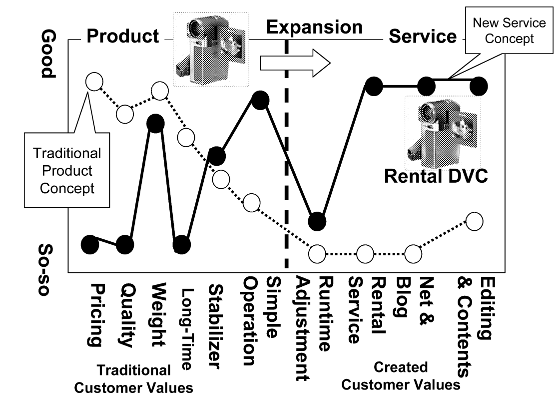


Fig. 8 Strategy canvas for DVC rental.

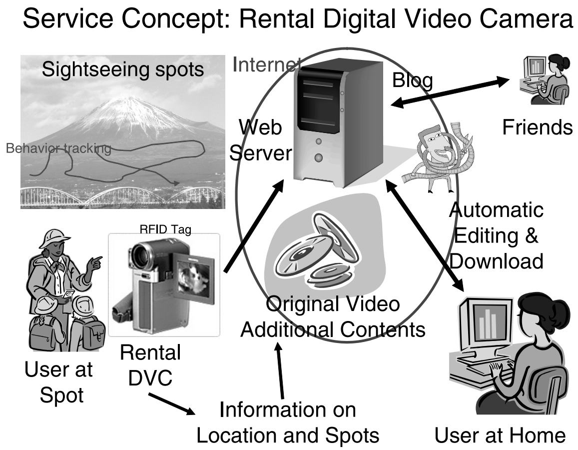
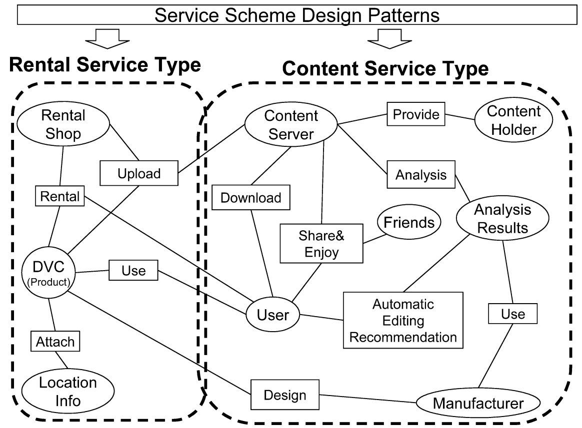
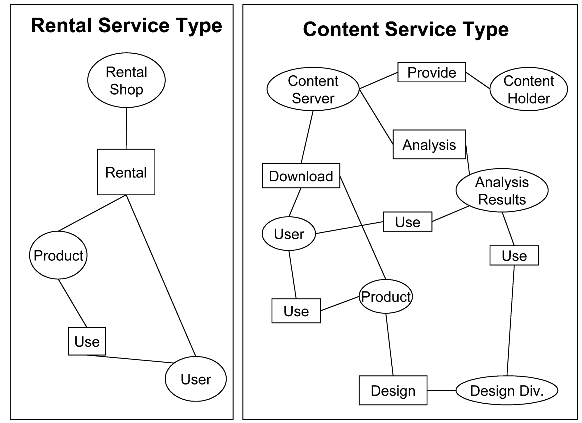


Fig. 9 Service concept for DVC rental.

(1) lending digital video camera (DVC) to a user at sightseeing spots and housing the video taken by the user, (2) downloading to the user's home PC and automatic editing of the video with additional location content (e.g., sightseeing spot information, background music), and (3) sharing and blogging the video and chatting about it with friends through the Internet (**Fig. 9**).



(a) Entity/Activity Chart



(b) Service Design Patterns

Fig. 10 Structure model (DVC rental).

Step 2: Service & operation scheme design

The designer describes an Entity/Activity Chart representing a structure model of the service (**Fig. 10** (a)). Here, the designer can describe the scheme by modifying two service design patterns (rental service type and content service type)

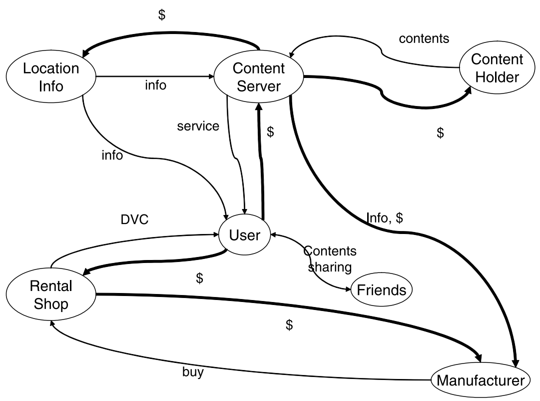


Fig. 11 Flow model (DVC rental).

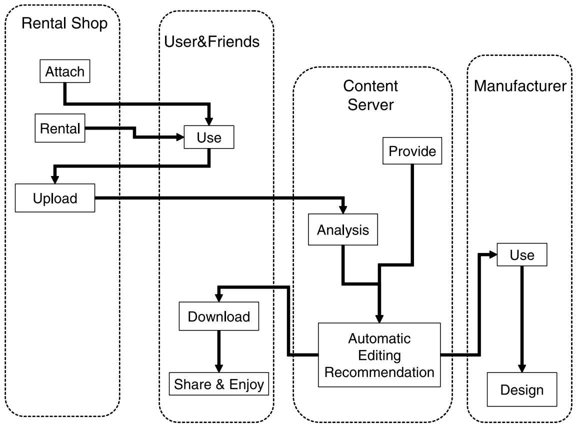


Fig. 12 Behavior model (DVC rental).

in the case database (Fig. 10 (b)). A flow model (CVCA) is constructed by extracting entities from the Entity/Activity Chart (**Fig. 11**), and a behavior model (Scenario Chart) is constructed by extracting activities from the Entity/Activity Chart (**Fig. 12**).

Step 3: Transformation design

For realizing the service scheme, the following organizational transformations

Failure Mode Checklist

Stage	ID	Failure Mode	Cause	Effect	Action	Rank
Development	B10	No service operation partner is obtained.	The forecast of a business model is too optimistic.	Withdrawal	Early withdrawal if no approval	2
	O5	Limited payout time	Unexpected large system investment	Replanning	Clear accountability	3
	B14	Poor Contents	Tourist agency's old attitudes	Limited attractiveness	Substitute content providers	4
Operation	B11	Limited to one sightseeing spot	Application is limited.	Restricted business scale	High margin model at specific spot.	3
	O6	Less Synergy with a DVC	Limited attractiveness of DVC functions	Less DVC div. commitment	Strengthening synergy of products and services.	5
	O8	Revenue share with partner	DVC profit is larger than service revenue	Partner disaffection	Design win-win structure	3
	B7	User are inelastic.	Preferable to take a photo with one's own camera	Service business loses money	Enhance attractiveness of services.	4
	B4	Strong competitors (e.g. film company)	Market entry is easy.	Cost competition and less margin	Erect a barrier by de facto standardization of a format.	5

Fig. 13 Project FMEA (DVC rental).

from a current organization (As-Is) to a target organization (To-Be) are required:

- Operation center (content server center) installation
- DVC rental shop chain construction
- Service personnel training
- Content provider exploitation (tourist information and video decoration content)

The way to achieve these transformations is described as a set of transformation scenarios.

Step 4: Risk analysis

Project FMEA (Failure Modes and Effects Analysis) is applied to a service scheme and organizational transformation scenarios (**Fig. 13**). Candidate failure modes (B10, O5, B14, B11, O6, O8, B7, and B4) are derived from a failure mode checklist (Fig. 1).

Step 5: Evaluation and Refinement

The designer evaluates a rough earnings model and risks, and describes the final plan for a decision-maker. The final plan consists of a service concept, a service scheme, transformation scenarios, and Project FMEA.

Table 5 Failure mode checklist and qualitative effectiveness of DFACE-SI.

Difficulty	Failure Mode	C	D	R	DFACE-SI Contribution
Structural Gaps between Product and Service Businesses	Less flexibility (O1)		X		Modify service scheme by flexible transformation through a trial and error process.
	Too technology oriented (O2)		X		Design non-technical scheme including organization.
	Shortfall in human resources (O3)		X		Design transformation scenarios including development of human resource.
	Sell-out preference (O4)		X	X	Design proper achievement objectives and share risks.
	Limited payout time (O5)		X	X	Design proper achievement objective and share risks.
Conflict among Stakeholders	Less synergy with product business (O6)	X	X		Share opportunities with stakeholders and clarify collaboration scheme.
	Lack of interorganizational coordination (O7)	X	X		Share opportunities with stakeholders and clarify collaboration scheme.
	Difficulty of revenue share (O8)	X	X		Share opportunities with stakeholders and clarify collaboration scheme.
	Negative effects of principle of precedent (O9)		X	X	Clarify collaboration scheme and reform stakeholder consciousness by sharing risks.
	Work speed conflict (O10)		X	X	Clarify collaboration scheme and reform stakeholder consciousness by sharing risks.
Poor Understanding of Service Businesses	Few experiences of service businesses (O11)	X	X	X	Recognize opportunities and difficulties by case analysis.
	Lack of system thinking & discussion (O12)	X	X	X	Think & discuss according to DFACE-SI.
	Insufficient knowledge sharing of success & failure cases (O13)	X		X	Recognize opportunities and difficulties by case analysis.
	Negative impression of services (O14)	X		X	Recognize opportunities and difficulties by case analysis.
	Ambiguous objectives (O15)	X			Recognize opportunities by case analysis.

C: Concept Generation Phase, D: Scheme & Transformation Design Phase,
R: Risk Analysis Phase, X: Contribution Phase of DFACE-SI

5. Qualitative Effectiveness of DFACE-SI

In this section, we show how DFACE-SI can contribute for users to overcome the following organizational difficulties, which were mentioned in Section 2.2 and Fig. 1.

- Poor understanding & decision of service businesses →
  Understand opportunities and difficulties adequately by referring concrete service cases and failure mode checklists in the database, and think systematically according to the DFACE-SI procedure.
- Conflict among stakeholders →

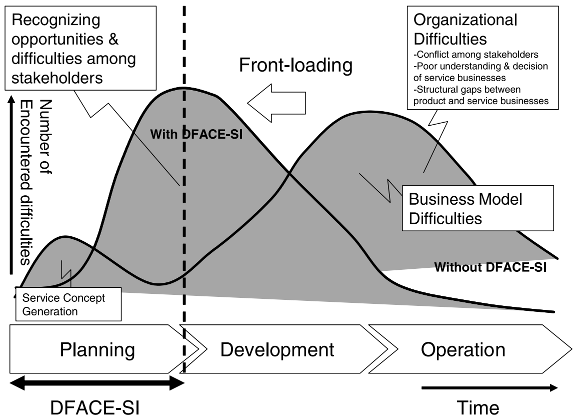


Fig. 14 Front-loading by DFACE-SI.

Share opportunities and difficulties using visual charts among stakeholders and clarify the collaboration scheme with re-forming stakeholder consciousness.

- Structural gaps between product and service businesses →
  Design service scheme and transformation scenarios with consideration of future difficulties by Project FMEA.

Table 5 shows detail relations between organizational difficulties and capability provided by DFACE-SI. Since the users can recognize opportunities and difficulties in the planning phase, it is possible to front-load countermeasures for overcoming these difficulties (**Fig. 14**). In our investigation, many product-based service projects have encountered serious difficulties in development and operation phases, which they have never expected in planning phase because of their inexperience.

6. Comparison with Related Works

We can classify new service development researches into 4 dimensions (**Fig. 15**). The vertical axis shows classification of general service or product-based service. The horizontal axis shows classification of analytic approach or synthetic approach.

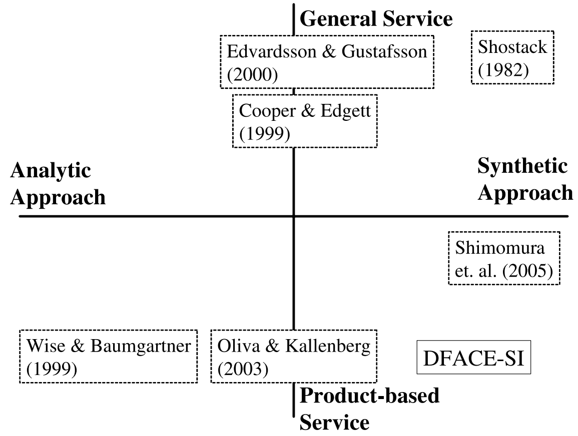


Fig. 15 Comparison with related works.

Cooper & Edgett [12] and Edvardsson & Gustafsson [13] have presented new service development methodologies. These approaches seem somewhat analytic since they provide no specific design charts and tools. Shostack [14] proposed useful and general service modeling tools (molecular modeling and service blueprint). These tools are designed for general services and do not consider characteristic features of product-based services. Wise & Baumgartner [3] show 4 types of business model of product-based services. This is thought-provoking but too analytic for traditional engineers.

Shimomura, et al. [15] have developed the most advanced synthetic approach (Service CAD) with which engineers are familiar. Compared with Service CAD, DFACE-SI focuses on product-based services and provides a service concept generation tool based on the customer contact expansion model in which 8 abstract functions are used as association keys for idea generation. DFACE-SI also provides risk analysis in light of difficulties that manufacturing companies may encounter in the organizational transformation.

Oliva & Kallenberg [16] show a 4-step transition process model as follows:

Step1: Consolidating product-related services.
Step2: Entering the installed base service market.
Step3: Expanding to relationship-based services or process-centered services.

Step4: Taking over the end-user's operation.
These transition processes include our three types of customer contact expansion (adjustment, commitment, territory). Furthermore, they mention difficulties of organizational transformation of manufacturing companies. This paper is highly suggestive. However, it is somewhat analytic and engineers require a more procedural design method. DFACE-SI can fulfill the engineers' expectations.

7. Conclusion

Recently, services sciences, management, and engineering (SSME) have attracted interest not only in academia but also in manufacturing companies [17]. However, there are few frameworks for analyzing and designing product-based service businesses [3),16)]. In this paper we have proposed a service design methodology for product-based service businesses DFACE-SI and apply it to a pilot case. Our approach is unique in providing a service concept generation tool based on the customer contact expansion model and in featuring risk analysis (Project FMEA) for organizational transformation. In our opinion, many Japanese manufacturing companies went wrong in organizational transformation even though they had good service concepts.

Subjects for future work include:

- Refinement of each step through application to many practical cases.
- Quantitative effectiveness measurement of DFACE-SI
- Modelling of service evaluation and pricing process.

References

1) Van Looy, B., et al.: *Services Management: An Integrated Approach*, Financial Times Management (1998).
2) Ishiyama, K.: TOSHIBA Management Innovation Deployment, *Journal of the Japanese Society for Quality Control*, Vol.33, No.2, pp. 154–160 (2003). (in Japanese)
3) Wise, R. and Baumgartner, P.: Go Downstream: The New Profit Imperative in Manufacturing, *Harvard Business Review*, Sep.-Oct., pp.134–141 (1999).
4) Vandermerwe, S. and Rada, J.: Servitization of business: adding value by adding services, *European Management Journal*, Vol.6, No.4 (1988).
5) Kameoka, A. (Eds.): *Research Report on Science and Technology for Service Innovation in Manufacturing Industry*, JAIST Report (2006). (in Japanese)
6) Uchihira, N. and Koizumi, A.: Classification of Services in Manufacturing Industry and Strategy of Knowledge Utilization, *21st Annual Conference of The Japan Society for Science Policy and Research Management*, 1B10, pp.33–36 (2006). (in Japanese)
7) Calthrop, P. and Baveja, S.S.: From Products to Services: Why it is not so simple, CEOFORUM (2006). http://www.ceoforum.com.au/article-print.cfm?cid=7207
8) Kim, S.K., Ishii, K. and Beiter, K.A.: Scenario Graph: Discovering New Business Opportunities and Failure Modes, *2007 ASME Int. Design Eng. Tech. Conf., ASME DETC2007-34967* (2007).
9) Ishii, K.: Course Materials, Design for Manufacturability (ME317), Stanford University, USA (2003).
10) Kim, W.C. and Mauborgne, R.: *Blue Ocean Strategy: How to Create Uncontested Market Space and Make the Competition Irrelevant*, Harvard Business School Pr. (2005).
11) Akao, Y.: *Quality Function Deployment: Integrating Customer Requirements into Product Design*, Productivity Pr. (1990).
12) Cooper, R.G. and Edgett, S.J.: *Product Development for the Service Sector*, Basic Books (1999).
13) Edvardsson, B., Gustafsson, A., Johnson, M.D. and Sanden, B.: *New Service Development and Innovation in the New Economy*, Studentlitteratur (2000).
14) Shostack, G.L.: How to Design a Service, *European Journal of Marketing*, Vol.16, No.1, pp.49–63 (1982).
15) Shimomura, Y., et al.: Proposal of the Service Engineering (1st Report, Service Modeling Technique for the Service Engineering), *Transactions of the Japan Society of Mechanical Engineers. C*, Vol.71, No.702, pp.669–676, (2005). (in Japanese)
16) Oliva, R. and Kallenberg, R.: Managing the transition from products to services, *International Journal of Service Industry Management*, Vol.14, No.2, pp.160–172 (2003).
17) Maglio, P.P., et al.: Service systems, service scientists, SSME, and innovation, *Comm. ACM*, Vol.49, No.7, pp.81–85 (2006).

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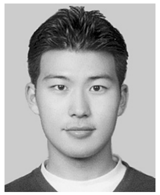

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