SERVICE SYSTEMS ENGINEERING: FRAMEWORK & SYSTEMS MODELING[1]

John Sum
Institute of Technology Management, National Chung Hsing University
Taichung 40227, Taiwan ROC
Date: January 2014

Abstract

Service science, management and engineering (SSME) have been intensively researched in the last couple of years. However, little has been done on providing framework to elucidate the scope and contents in the three major disciplines in SSME, namely service science, service management and service engineering. In this paper, a framework for service engineering (or service systems engineering) is presented; and the differences amongst service engineering, service science and service management are identified and the models for service systems modeling are presented.

To lay the framework for service engineering, the context of a service system is discussed and the process of service engineering is defined. By that, the relations amongst service engineering, service science and service management elucidated. We perceive a service system as an ecosystem[2] composing of people, process (i.e. the service delivery process) and tools/technologies; and its purpose is to deliver quality service to its end customers (or service consumers). Thus, we adopt the IEEE definition of software engineering and define service engineering as a system development process based on the application of a systematic disciplined, quantifiable approach to the development, operation, maintenance of service systems. Service engineering process consists of multiple stages namely analysis, design, implementation and maintenance. With the above definition on service engineering, we are able to identify clearly the similarities and differences amongst service engineering, service science and service management. Service science focuses on understanding the behaviors of a service system like an organization or a service ecosystem which consists of many organizations. By understanding, it refers to system modeling and system analysis. The behaviors could refer to the performance, the service quality, the competitiveness and the social impacts of the service system. To be science, the models have to be formal. Analysis has to be analytical. For complex service systems, extensive com-

[1] Part of the work presented in this paper is prepared by my master student Luke Zong-Huan Xie and students who have taken the course *EC Websites Development*. Their contributions have to be acknowledged.

[2] By Wikipedia, an ecosystem is a community of living organisms (plants, animals and microbes) in conjunction with the nonliving components of their environment (things like air, water and mineral soil), interacting as a system. Note that we are able to use the terms socio-technical system and business ecosystem referring to a service system. For simplicity, we use ecosystem throughout the paper referring to a service system.

puter simulations have to be conducted. In this regard, theories in stochastic processes and operations research, and techniques in computer simulations will be applied. With reference to the five-stage process model for service engineering, the works to be done in the analysis stage and design stage are essentially the same as the works to be done in service science. Except that attaining optimal design is not a goal in service science. Note that the scope of service science is not limited to the analysis of service systems within an organization. All kind of service systems existing in the world are the interests in service science. Service management refers to managing the processes (service delivery process and other supporting processes), the people and the tools within an organization in order to deliver quality services/products to the end customers and managing the services for managing the usage and the development of the services. Management processes include order fulfillment, human resource management, supply chain management, customer relationship management, marketing and financing, and information management. The definition of the tasks to be accomplished in each of these management processes have to be done in the stages of design, implementation, and maintenance and review. In the design stage, service manager has to make sure that the service deliver process is practical and accountable. The organization structure is feasible. In the implementation stage, service manager has to track the progress and make sure the implementation can meet the schedule. The performance of the service system fulfils all the performance indices being set in the design stage. In the stage of maintenance and review, service manager will have to monitor both the performance of the system and the customer perception on the service quality. Reviews are conducted in regular basis. In other words, it refers to the management of all the operations within an organization. Note that managing service marketing is a task but not the only focus in service management.

About service system modeling, it is surprisingly that little progress has been achieved in last decade. One reason we suspect is the lack of “unified” modeling language that can be adopted by both the technical expertise and the management professionals. Engineers and scientists rely on UML and mathematical models to visualize a system, while management professionals rely on service blueprint and GAP model. It is clear that communication gap exists in between these two groups of professionals. In this regard, we summarize a number of diagrams which can aid the design and analysis of a service system. Some of them are extracted from the UML and some of them extracted from the literatures in service marketing. Cases are presented to illustrate the use of these diagrams and models.

Apart from laying the framework for service engineering and suggesting models for service systems modeling, some related issues are discussed. One is about the concept of technology management in SSME. We argue that technology management and

SSME are closely connected. T-shape professionals are not able to be trained in college. On the contrary, T-shape professionals are naturally evolved if they have been working many years in the industry with enough experience in service projects. Then, a few definitions on service are reviewed. The evolutionary and diversified natures of services are commented.

Keywords: Models, Service Engineering, Service Management, Service Science, Service Systems, Service Unit, Technologies

1. INTRODUCTION

For half a century, service has always been an important topic to both the academicians (Regan, 1963; Levitt, 1972, 1976; Hostage, 1975; Sundbo, 2002; Buera & Kaboski, 2009) and non-government agencies (Fuchs, 1968a, 1968b, 1977, 1982; Kim, 2007; OECD, 2000, 2005, 2007) that have interests in the practices in service sector and factors governing the raise of service economy. While the definitions of service science, service management and service engineering have been presented (Maglio, Srinivasan, Kreulen, & Spohrer, 2006; Spohrer, Maglio, Bailey, & Gruhl, 2007), their definitions are too rough to identify the differences and similarities amongst these sub-disciplines. Nonetheless, comparison between SSME and other existing disciplines like computer science and engineering, software engineering, industrial engineering, management science and social science, have not been conducted. Thus, the objective of this paper is to lay a process framework for service systems engineering and suggest models for modeling service systems. By using such models, managerial personnel, operational staffs and IT professionals are able to communicate and then work out the design of a service system.

1.1 Researches in SSME

In recent decades, the context of SSME have been explored by many researchers in the service management and marketing communities for the strategies for the design of services and the corresponding delivery processes so as to gain customers experience, to improve management efficient of the delivery processes and to strive for better marketing strategy of the services.

To define SSME as a discipline, a lot of works have been done in the last couple of decades. (C. H. Lovelock, 1983) has made a comprehensive review on different types of services and revealed that managerial strategies are different from one service category to another. Recently, Christopher Loverlock and Evert Gummesson (C. Lovelock & Gummesson, 2004) reviewed literatures on the definitions of services and advocated the abundance of the traditional definition of services by intangibility, heterogeneity, inseparability and perishability. Instead, a new paradigm on service should shift to ‘consider services offer benefits through access or temporary possession, instead of ownership, with payment taking the form of rentals or access fees’.

Apart from defining service and service systems, some researchers suggested models[3] for the design of a service deliver process (Bitner, Ostrom, & Morgan, 2008; Glushko, 2008; McKay & Kundu, 2011; Patrício, Fisk, & Cunha, 2008; Patrício, Fisk, Cunha, & Constantine, 2011; Shostack, 1982, 1984; Zirpins, Baier, & Lamersdorf, 2003). These models are basically evolved from Shostack's service blueprint. A service blueprint elucidates the steps a customer gets the service from the service organization and what activities the service organization has to do in the process of interaction. Bitner et al (2008) have argued that service blueprint is a simple model as compared with UML. However, they overlooked that service blueprint is essentially the sequence diagram in the UML. Thus, both service blueprint and sequence diagram can only model the operation of a single service delivery. To have a complete analysis and design a service system, it is necessarily to consider a bigger picture which includes all service delivery processes, all types of customers and how the organization is organized to support the services (Böttcher & Fähnrich, 2010, 2011, 2013; Demirkan & Dolk, 2013).

To assess the quality and the performance of a service delivery, some researchers particularly in the service marketing area proposed different types of service quality measures[4] (Barrutia & Gilsanz, 2013; Grönroos, 1984; Parasuraman, Zeithaml, & Berry, 1985, 1988; Seth, Deshmukh, & Vrat, 2005). The fundamental idea of these measures is based on concept of 'GAP', the gap between the quality standard set by service provider and the quality perceived by the service consumer. From these quality measures, strategies to improve service quality are thus suggested (Bitner et al., 2010; Glushko & Tabas, 2009; Hostage, 1975; Jiang, Klein, Tesch, & Chen, 2003; Lin, 2008).

As a service system is yet another system, some researchers mostly from systems and industrial engineering laid the methodologies[5] for engineering service systems (Arsanjani et al., 2008; Berg, Tien, & Wallace, 2001; Bullinger, Fähnrich, & Meiren, 2003; Carbone & Haeckel, 1994; Cardoso, Voigt, & Winkler, 2009; Chen, Perry, & Kazman, 2009; Chen, 2008; Hara, Arai, & Shimomura, 2006; Hsiao & Yang, 2010; Luczak & Gudergan, 2010; Margaria & Steffen, 2006; McFarlane, 2011; Scheithauer, Voigt, Winkler, Bicer, & Strunk, 2011; Tien & Berg, 2003a, 2003b; Wu & Wu, 2010; Zhang, 2009). As witnessed the raise of the experience economy (Chang, Yuan, &

[3] We call the former model the process model and the latter model the system model.
[4] We call these quality measures the quality models.
[5] In this paper, methodology and framework are used interchangeably.

Hsu, 2010; Pine II & Gilmore, 1998; Pine II & Victor, 1993), many researchers laid the methodologies for engineering service systems with special focus on customer experience (Carbone & Haeckel, 1994; Hsiao & Yang, 2010). All these methodologies could be interpreted as extensions of the methodologies in software engineering, new product development and systems engineering with shifting focus on services.

To advocate the need of SSME professionals, some researchers worked on the curriculum design for making SSME as an education program (Bitner & Brown, 2006; Y. Chen & Tsai, 2011). While there are a number of SSME programs launched in the last decade, not many new programs has been started in the recent years.

1.2 Unresolved problems

Although many works have been done in the last decade, a couple of research problems are yet to be resolved. First, extended work along the design models for service delivery process to the development of information system and technologies is scarce. Information systems and technologies are inevitable components in an organization. However, current researches in services normally treat the development of an information system and the development of service delivery process as two independent issues. Modeling of a service delivery process by using service blueprint stops short on the front end and back end staff. Modeling information system is not considered. Clear, communication gap would easily appear between operational staffs who use the information system and the developers who build the information system. One possible reason is the lack of common models for the operational staffs (or management professionals) to express the system requirements in a way that the developer is able to understand and the system developers to express the system design to the operational staffs. Second, complexity issue has not been aware in the service research community while it has long been aware in organization theory, advocated by Herbert Simon (Simon, 1962). To analyze the complexity of a service system, models other than service blueprint must be applied. Third, SSME is still a fuzzy discipline. Although many researchers have been defining the area, they have not clearly differentiated the differences amongst SSME and the existing disciplines. For instance, the similarities and differences between service science and computer science have not been discussed. The similarities and differences amongst service management and other disciplines in management have not been clarified. These are just examples. There are a lot more conceptual questions waiting for clarification.

1.3 Statement of research

Without in-depth analysis the relations amongst SSME and other disciplines, a complete picture of SSME can never been achieved. In this regard, this paper serves as the first step towards a framework for SSME with emphasis on service systems engineering and service system modeling. The models being selected are simple enough for management, operational staffs and IT professionals to understand the essential aspects of a service system.

1.4 Organization of the paper

In the next section, the concepts of service systems are elucidated. Then, a process framework of service systems engineering will be described in Section 3. Essential models for system modeling are described in Section 4. A case study on the use of these system models for a business service is presented in Section 5. Section 6 discusses other issues related to service science. The conclusion of the report is presented in Section 7.

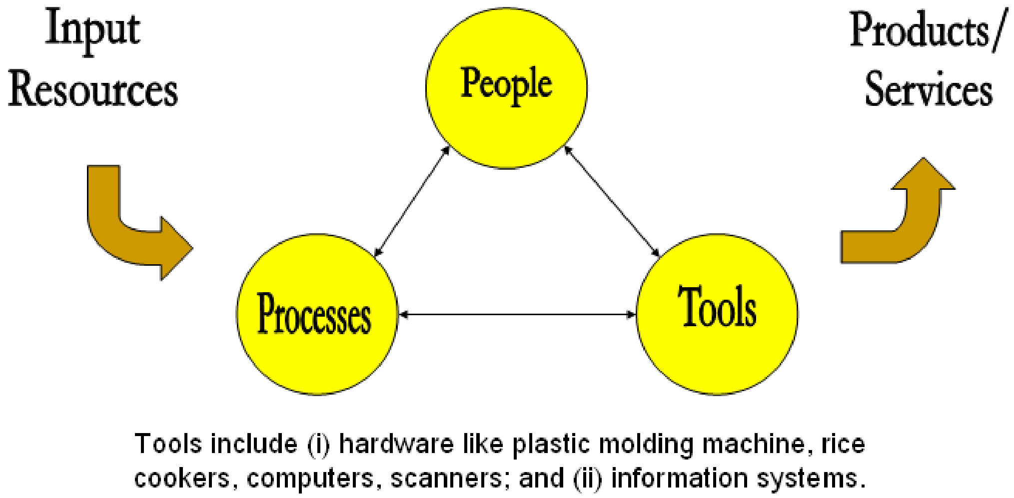


Figure 1: Conceptual idea of a service unit.

2. SERVICE SYSTEMS

In accordance with IBM, SSME is an interdisciplinary approach to the study, design, and implementation of service systems – complex systems in which specific arrangements of people and technologies take actions that provide value for others. This definition although seems general enough to cover everything called service system, it is however too general that key topics and issues to be concerned in the science nature of the service systems, the management of a service system and the process to engineer a service system are overlooked.

The very first principle underlying SSME is that the context of SSME should be applicable to different service systems, like health care, telecom service, Internet service, cloud service, logistic services, public transportations, finance, education, travel, hotels and restaurants, and technology consultant services (see Figure). These industries have quite diverse natures. Some of them are labor intensive, like hospitality services and food services. Some of them are basically computational machine intensive, like telecom service[6], Internet service and cloud services. Their core services are provided entirely by computer programs and servers.

[6] It should be noted that the telecom service is evolved from labor intensive to machine intensive. In the old days, connecting two telephones (i.e. switching) was done by operators. Until the invention of electric switchboard, the work done by operators is replaced by electronic switchboard. Please see Wikipedia "Telephone Switchboard" for detail.

Figure 2: Examples of services

2.1 System

Service system is simply a system delivering quality services to its customers. By no means, a service system is composed of many interrelated sub-systems called service units. Each service unit is made up of people, processes and tools. Each service unit provides services to other service units and/or the end customers. In addition to the service suppliers and the customers, a service system can be viewed as an eco-system. Figure 1 shows the conceptual idea of a service unit. The people in the system can be further categorized as (1) people who involve in delivering services and (2) people who consume the services. Processes are referred to the operational procedures in which the services are delivered. Each service unit provides services to other service units and/or customers. Follow Zhang (2008) services represent a type of relationships-based interactions (activities) between at least one service provider and one service consumer to achieve a certain business goal or solution objective. Service unit is the atomic unit (generic component) in a service system. It takes resources (data, information, raw materials or services) from other service units and then produces services (sometimes with physical products) to other units and/or customers. To this end, a service system is essentially a socio-technical system.

Exemplar service systems are huge, including health care center, a hospital, a university, a government, a telecom, the Skype, a webmail system, a bank, a network administration support team, a restaurant, a library and a car repairing workshop. Some of these service systems, like hospital and government, provide complex services. Some systems, like Skype and webmail system, provide simple services. Here, we define complexity of the services delivered solely based on complexity of the core services. Supporting services are not accounted for. In a university, educating students is the core services provided by a university. Therefore, the complexity of an academic program (as a service) is evaluated by the size of the academic department offering the program, the number of laboratories, the size of the program committee and the number of regular meetings. Supporting services including accounting, course registrations, computing services, dormitory, restaurants and library will not be accounted for. Webmail systems, like Gmail and Yahoo, provide simple service. The core services provided by Skype are simple VOIP services, see Figure 2. The core services provided by a telecom are simply phone call connection and Internet access service. They are simple services. However, to complement the core services, telecom would also have their customer service center, marketing department, accounting department, and others.

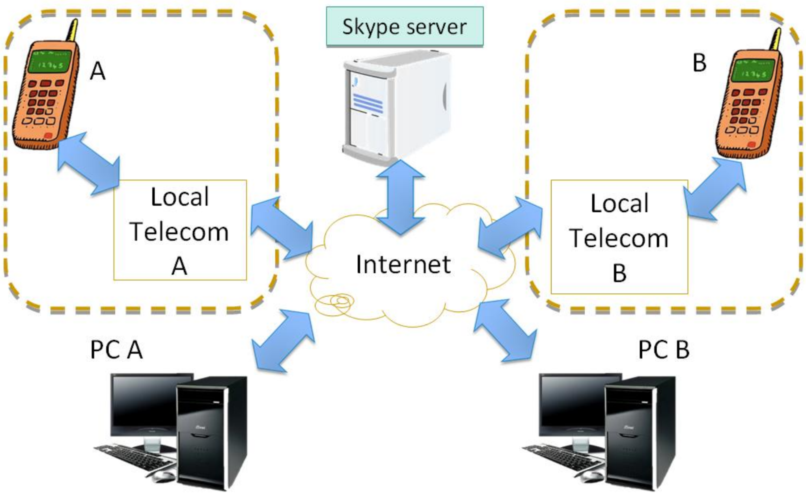


Figure 3: A service system can provide more than one services. Skype services include PC-to-PC VOIP calls, video conference, Skype In (telephone call in) service, Skype Out (call out to telephone) service and Phone-2-Phone service. Owing to provide all those services, Skype needs to seek for support from various local telecoms.

Figure xx shows a generic diagram of these intricate interactions within an organization.

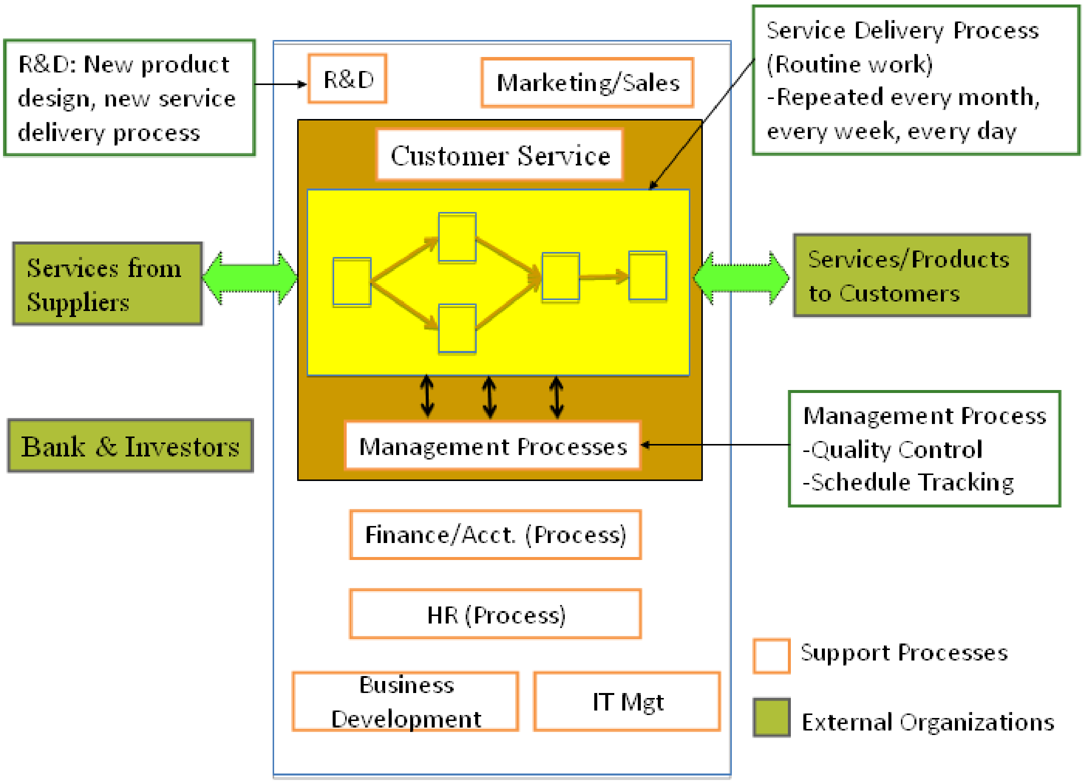


Figure 4: Intricate interactions within an organization.

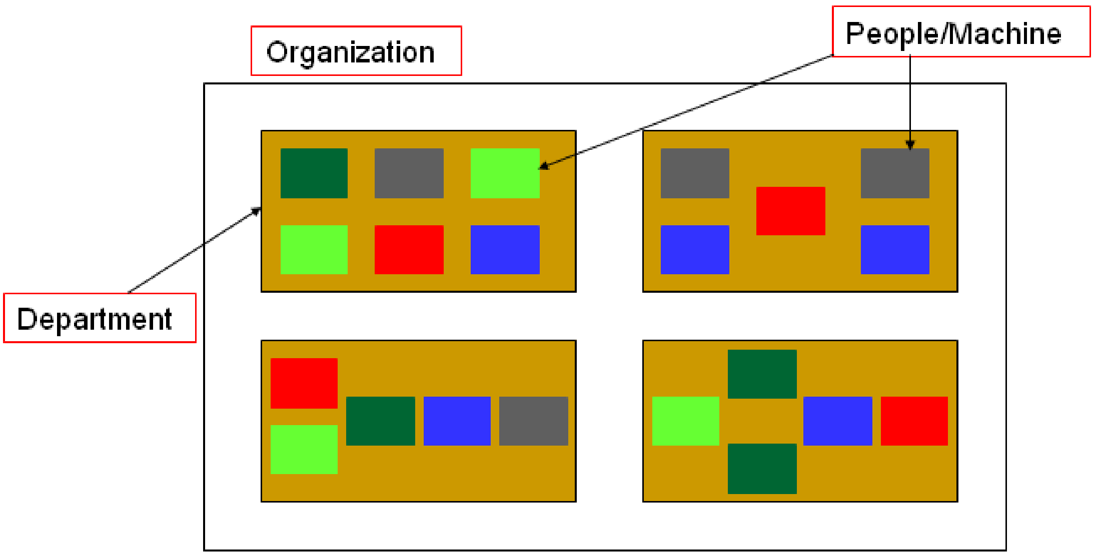
2.2 Service Units

As mentioned in the precedence subsection, each service unit is made up of people, processes and tools (see Figure 1). Each service unit provides services to other service units and/or the end customers. One should also note that a service system itself is a service unit if we consider an organization as part of the industry. Here, we do not intend to give a clear distinction between service system and service unit.

Technologies (or tools) are used by both the people who deliver the service and the people who consume the service. Here, tools are not limited to information technologies. It involves a lot more other things. For instance, DHL provides on-line cargo tracking system for their customers to keep track of the routing information of their cargos. At the same time, DHL makes use of the cargo loading equipments to facilitate the workers to do the upload. The former system is clearly an information system which is built upon information technologies, while the equipments are tools. The tools are built upon mechanical technologies.

It should be noted that people might not be necessarily involved in a service unit. Take telecom service as an example. In telecom, service is entirely provided by the switching machines which are operated by computer programs. Skype provides service entirely by the programs running in the server and the programs installed in the users computers. Except administrative and managerial workers, technicians and engineers, no person is involved in delivering the core services.

It is clear that a service unit can be itself a service system. Figure 3 shows the schematic diagram of an organization as a service system. The departments (process units) are service systems. The working teams in a department are service systems. In this regard, an organization can also be defined in layered structure, Figure 4. From the information system perspective, an information system can be a service system. Software, platform and infrastructure can also be defined as a service system. Infrastructure provides services for making better platforms and software. Platform in turn provides services for making better software.



Three levels of views of an organization: (1) Organization as a PS System (2) Department as a PS/S System, (3) People/Machine as a PS/S System

Figure 5: An organization, a department and a departmental unit can be viewed as a service system.

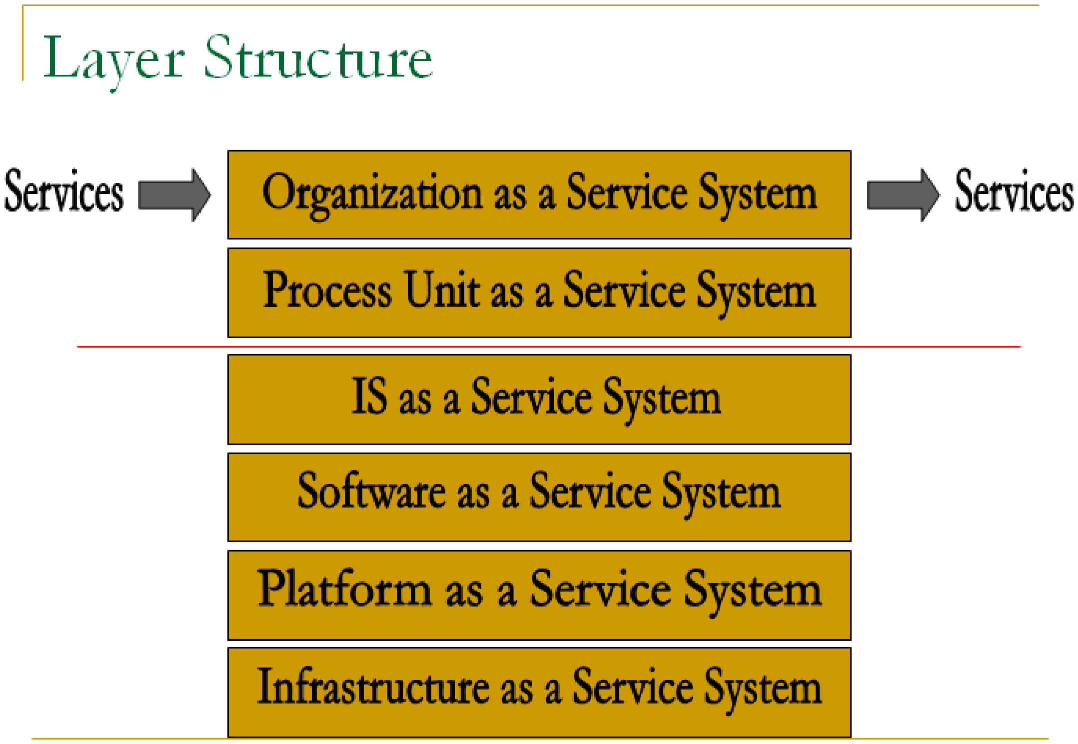


Figure 6: Organization as a service system and the layer structure of an organization. Systems in the lower layers provide services to the higher layers. Service units could provide services to other service units within the same layer.

2.3 Service Science

While we focus on the scientific nature of SSME, we call it Service Science. To be 'science', it must be doing something related to the laws of nature, just like what physicians and scientists work on our world. The problem interested in Service Science is about the definitions, the models, the ecologies and the analysis of service systems (or a system of service systems). It is about how to model a worker, a department (if we treat a department as a service unit) an organization (if we treat an organization as a service unit) and a cloud (cloud as a service unit). By using such models, we are able to analyze the performance (such as completion time and the service quality) of the system by mathematical analysis or simulation. Analysis results would help us better understand the behavior of a service system. Moreover, we can simulate the behavior of a service system if exceptional situations are encountered.

Our definition of service science is also different from others. Bitner et al (2008) stated that services science is an emerging discipline that focuses on fundamental science, models, theories and applications to drive innovation, competition, and quality of life through services.

2.4 Service Management

We agree that SSME is a management discipline. Two important issues in Service Management are (1) how to manage the marketing and delivery of quality service and (2) how to manage the design (development) of a new service. No wonder, the topics like service marketing, service blueprint, service gap analysis, SERVQUAL (Parasuraman, A., Zelthaml, V.A. & Berry, L.L. 1985) and service design are included. For more than two decades, service management and service marketing have been studies intensively in the service industry and now they have been well established in the area of management.

2.5 Service Engineering

We also agree that SSME is an engineering discipline simply because it is talking about how a new service could be designed (development). The idea is also similar to what people called business process re-engineering that appeared in the earlier 1990s. Service Engineering is (1) the application of a systematic disciplined, quantifiable approach to the development, operation, maintenance of service systems; that is the application of engineering to service systems. (2) The study of approaches as in (1).

Service engineering is a process for service systems development, and a guideline for the people involved in development, usage and management of the new service system. To understand and analyze a service system, we need the layer structure as a model of reference. To understand how it can be developed, we need system development life cycle to elucidate the steps in the development process. Five steps are included in the model, Figure 5. They are (1) System Analysis, (2) System Design, (3) Implementation, (4) System Testing, (5) System Maintenance and Review. Figure 5 and Figure 6 also show the relations amongst service engineering, service science and service management. In the subsequent chapters, their similarities and differences will be elucidated.

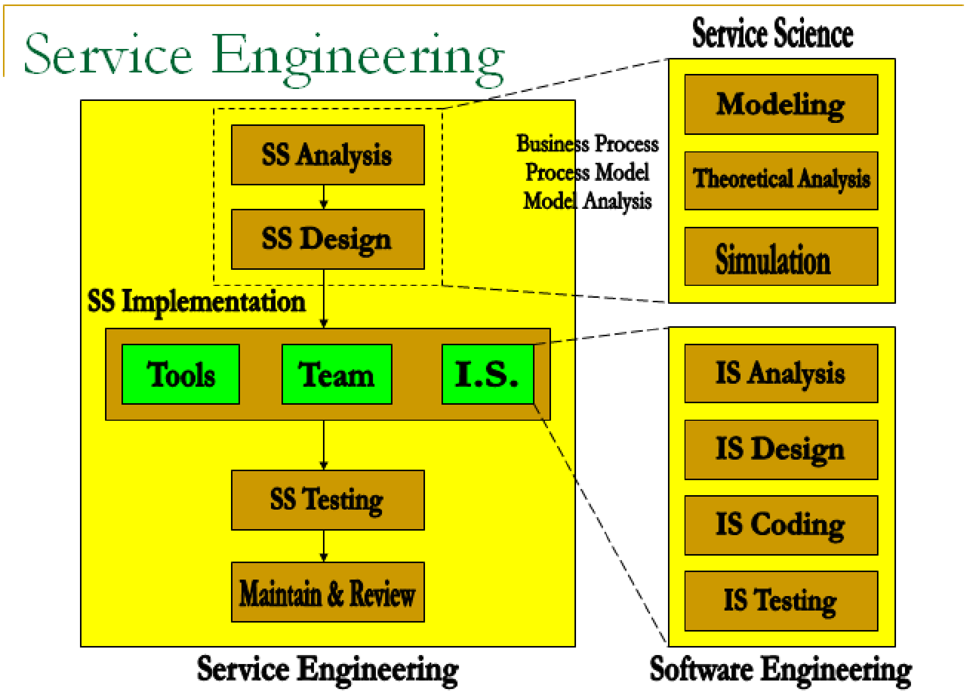


Figure 7: Conceptual framework of service engineering. SS refers to service system, while IS refers to information system.

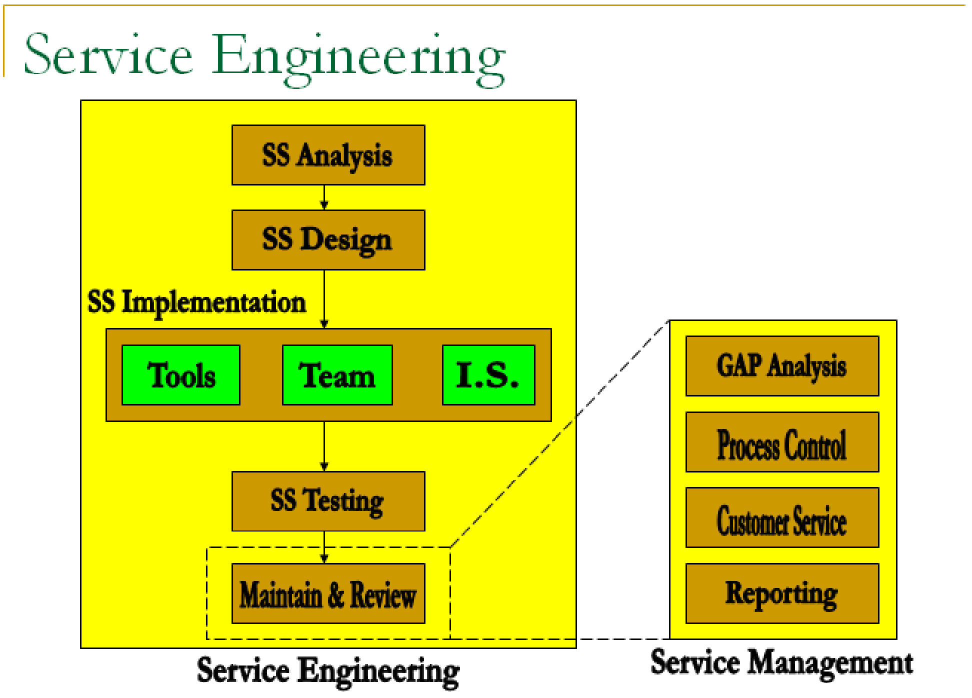


Figure 8: Service engineering and service management.

3. SERVICE SYSTEMS ENGINEERING

The ultimate objective of service engineering is no difference from the objective of software engineering, industrial engineering, information system development or new product development, that is, to give a step-by-step guideline (engineering steps) for practitioners to produce high quality stuff to the customers. In other words, service engineering concerns how to engineer a service system so that it can deliver high quality services to its customers. To clarify this point, one could think of mobile phone service that we enjoy everyday. Telecom is a service system. The core services provided by such a telecom include Internet access service and 3G mobile service. Another example that we can think of is a restaurant. A restaurant is a service system. Delivery delicious cuisines and comfortable dining environment are the services provided.

All these service systems share some common features. Each of them consists of various process units (service units, or departments) that provide services to other process units. Some of them provide services directly to the end customers. Some process units are labor intensive, customer service center for instance. Some of them are basically machine oriented, the switching machine in a telecom for instance. To this end, service engineer needs to understand that services delivered amongst a service system consist of face-to-face services (F2F services) face-to-machine services (F2M services) and machine-to-machine services (M2M services). Without proper understanding how a customer and a staff member would like to interact with the other service unit, the interaction amongst difference service units and the customers could be problematic.

There is another objective why we need to understand service engineering, that is, to reduce the communication gaps. Clearly from Figure 7 that communication gaps exists everywhere in a service system. An organization could misunderstand the expectation of the customers on service quality. While designing the business processes, customer expectation has not been taken into account. Even the business processes are properly designed, operational staffs might fail to follow the procedures. Thus, high quality service is unable to deliver. Nevertheless, information system developers might fail to specify the system requirement and the user interface design, such as how the customers, operational staffs and the managers use the system. Note that the gap between the users and the developers of an information system has usually been ignored in the service marketing and service management communities.

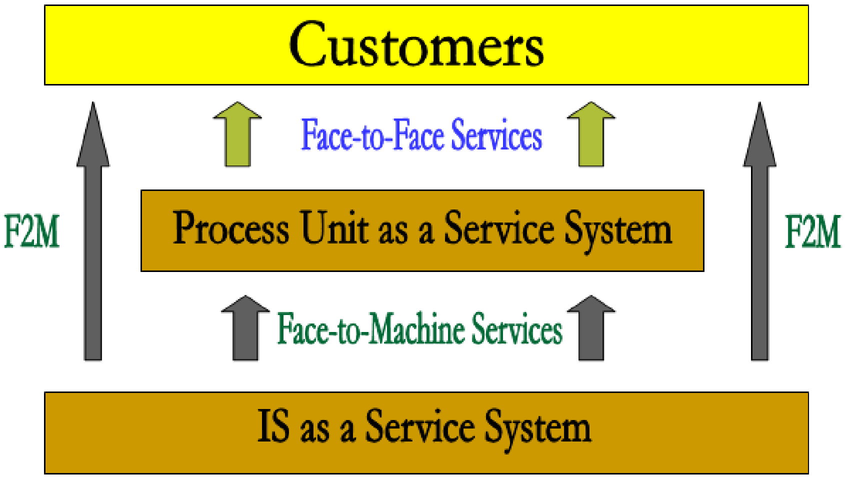


Figure 9: Types of services delivered within an organization.

3.1 Framework

We perceive a service system as an ecosystem composing of people, process (i.e. the service delivery process) and tools/technologies; and its purpose is to deliver quality service to its end customers (or service consumers). Thus, we adopt the IEEE definition of software engineering and define service engineering as a system development process based on the application of a systematic disciplined, quantifiable approach to the development, operation, maintenance of service systems. Service engineering process consists of multiple stages namely analysis, design, implementation and maintenance.

The aim of the first two stages is to attain the optimal design of the service system to be launched in the future. The works to be done in the stages of analysis and design include (i) transforming the verbal definition of the system to a serious of system models (via informal models like service blueprint and formal models like sequence diagram) (ii) analyzing the system model via analytical analysis and computer simulations; (iii) based on the analysis result giving the optimal design on the service delivery process and the service system (i.e. the organization structure). Specifically, the design includes the definitions of the service delivery process and the processes monitoring the quality of service, the roles of the suppliers & customers, the key professionals to be involved and their job descriptions, the organization structure, the operation manual, and the requirement specifications of the tools, technologies and information systems. Moreover, the key performance indices and the level of quality are defined.

In the implementation stage, the tools, the technologies and the information systems are built (or acquired). The staffs are trained to do their jobs. After that, it comes to the stage of system testing. The service delivery process can be testified by running rehearsals to make sure that the system is able to meet the key performance indices and the level of quality.

If everything is fine, it comes to the stage of system maintenance and review in which the system is launched and customers are able to get the service from the organization. The service management process puts in place. Reviews on both the performance of the system and the customer perception on the service quality are conducted in regular basis. A major challenge in service engineering is in the stages of implementation and testing. As customer is normally not involved in these stages, the true customer perception on the service quality cannot be obtained. We can only rely on the feedback and comments from the employees to examine if the performance of the service delivery process is acceptable.

3.1.1 System Analysis

The key in system analysis is to analyze the performance and identify the potential problems in the existing service system. The main task is to model and analyze behavior of the existing service delivery processes. If there are serious problems regarding the existing system or the existing system is unable to support new services. A new system will need to be defined. In other words, we need to analyze both the existing system and the future system.

To analyze existing system, GAP model and SERVQUAL are definitely useful. It can help analyzing the quality of the face-to-face and face-to-machine services. Other measures should be designed for measure the quality of the machine-to-machine services. In this stage, if the analysis result is negative, we should propose if any new services should be added or any modification should be made on the existing processes. If new services (or products) are delivered, analyze if the existing service system is able to support. If it is not, analyze how the system should be modified and what new components should be added to.

Requirement analysis is also conducted in this “System Analysis” stage. Four requirements are particularly importance. Functional requirements refer to what services are provided for the users and for other systems. Quality requirements refer to the response time, throughout, resource usage, reliability, availability, recovery from failure, allowances for maintainability and enhancement, allowance for reusability. Platform requirements refer to what computing platform and technologies have to be used. Process requirements refer to the development process being used, the cost and the delivery date.

Useful modeling tools for the analysis and design of a service system include service blueprints (from service marketing perspective) data flow diagrams (from structural analysis perspective) and unified modeling language (e.g. use case diagrams, sequence diagrams, state diagrams, etc.). These models can help to describe the business processes. First, one can start from use case diagrams to outline the business models in which the service to be delivered are shown. Second, the steps in which the service is delivered are detailed in the service blueprints and sequence diagrams. Focuses are put on the identification of the service processes that is supposed to be blueprinted, the identification of the customer segment or the customers that are supposed to experience the service. Moreover, the services perceived by the customers should be documented. The actions to be taken by the contact employee (onstage and backstage) and the customers have to be clearly drawn. If technologies (like information systems) are needed for supporting such services, definitions of such technologies have to be clearly stated. If performance of the system has to be evaluated, one can apply SERVQUAL to obtain quantitative measure on the perceived quality and thus apply GAP model to analyze the communication gaps within service system.

To be more precise, a system should be defined mathematically. Thus, we can define the revenue model, the cost model and the service delivery model in mathematical equations. Theoretical analysis on those models can thus been possible. In case the models are too complicated, one can apply simulation techniques to study those properties. Please refer to the top right hand corner in Figure 3. For sure, if the future system is defined and modeled, theoretical and simulated analysis can then be done. Analysis results can thus be taken into account for the management team to make decision whether the new service should be launched. Moreover, researchers can visualize the behaviors of the service systems if exceptional situations occur. Analysis will be re-done once system design has been finished. Later in the text, we will discuss further on this modeling issue.

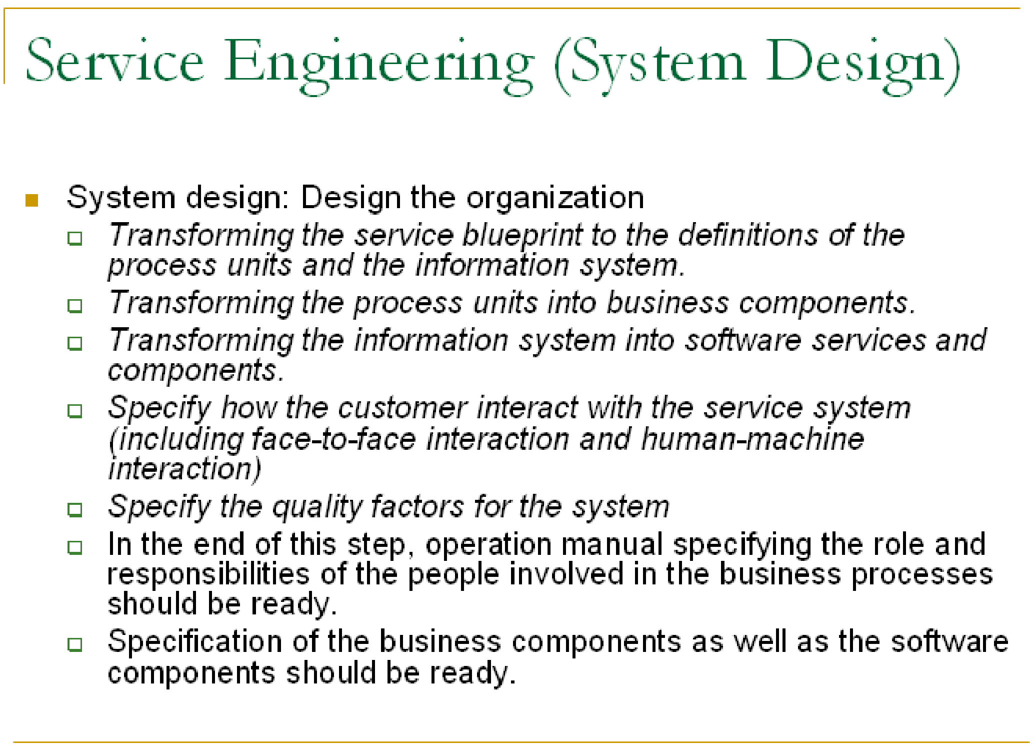


Figure 10: Tasks to be done in service system design.

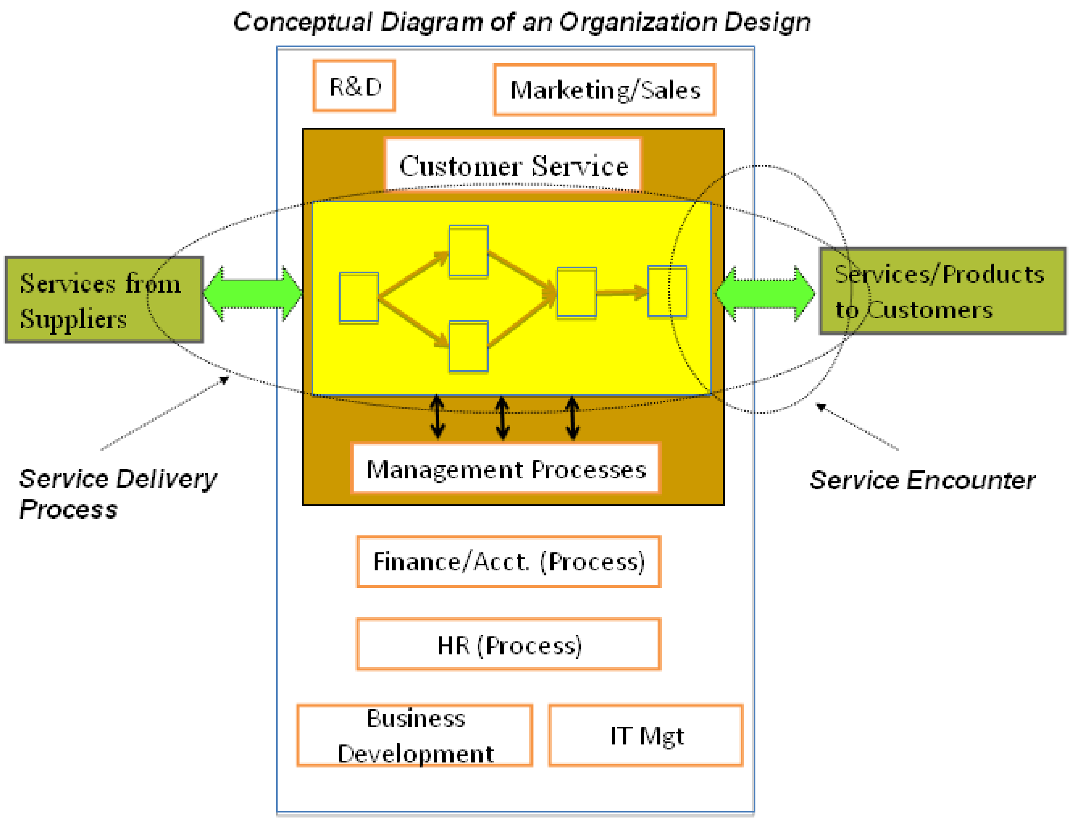


Figure 11: Conceptual diagram of an organization design.

3.1.2 System Design

System design is talking about designing the organization that is going to deliver the service. In this stage, the service blueprints are transformed to the definitions of the process units and the information system. Process units are transformed into business components. Information systems are transformed into software services and components. The design diagrams specify how the customers interact with the service systems (including face-to-face interaction and human-machine interaction). The quality factors for the system are specified. In the end of this step, operation manual specifying the role and responsibilities of the people involved in the business processes should be ready. Organization chart will be ready. Specification of the business components as well as the software components should be ready.

Specific documents include (1) service manual for customers, (2) operation and training manual for staffs, (3) specifications of the information system, (4) the design of the tools, (5) system testing procedures and (6) anticipated performance of the system. These documents will be used in the next two stages for the implementation and testing of the service system. Moreover, these documents will be used for the development of the standard operation procedure (SOP).

Once a system has been designed, we will have a bunch of models including service blueprint (process model) and the business components (service units). The activities in each business component are defined precisely (and even mathematically). The interactions amongst the business components are also defined precisely (and even mathematically). Simulations, if possible, should be conducted to investigate the behaviors of the system under different environments (including exception situations). Theoretical analysis, if possible, should be conducted to prove the behaviors and identify potential risk behind. Simulations and theoretical analysis are the analysis done after the system design. They aim to identify potential problems that might occur after the system is implemented. Besides, system will be re-designed for system optimality.

The final task to be done in system design is to decide if (1) the development of the information system, (2) the recruitment and training the team and (3) the development of the tools should be outsourced.

3.1.3 System Implementation

After the service system has been designed, the specifications of all the business components, software components and the related tools have been finalized. Therefore, in the stage of system implementation, the focus is on (1) team building, (2) information system implementation and (3) tools building. For the business components, staff members are trained to execute the process flows. It is the *team building*. In this stage, it is assumed that the information system is ready to use. *Implementation of an information system* follows the steps in software engineering which includes analysis, design, coding and unit testing. Here, it is assumed that the people know how to use the software components. If special tools are needed, those tools would need to be implemented as well. It is the *tools building*. Successful implementation of a service system requires professional knowledge from various disciplines. Team building, information system implementation and tools building are done in parallel. Once everything has been completed, the final step in this stage is to conduct a dry-run to testify if there is anything missing.

No matter the implementation is done in-house or it is outsourced to consultant firms, managing implementation requires knowledge in project management. In particular, project scheduling and project tracking are two important management tasks facilitating the success of implementation.

3.1.4 System Testing

During the system implementation stage, only the staff members are involved in preliminary testing. In this system testing stage, customers must be involved. Moreover, the service system must be testified under various conditions, including normal condition, exceptional condition and extreme condition. All the people involved in the business process and the information system are ready. The process flows are re-run to see if there is any discrepancy between the design specification and the actual process flows. To check if the performance of the overall service system fulfills all the quality factors. In this stage, customer feedback has yet to be collected. So, testing of the service flow could only be accomplished by inviting special guests, staff members in the organization to join the testing programs.

Two critical factors governing the success of system testing are (1) the testing plan and (2) the feedback. Testing plan should be ready once after the system has been designed. Anticipated problems should have been identified and recovery plans should be prepared during the system design stage. Furthermore, the testing plan should be comprehensive and yet simple enough for identifying the critical steps in the process flow. For the feedback, it will largely depend on the experience of the people involved in the testing programs. Suppose the staff members are not frequent travelers. It is unlikely for them to comment on the quality of a hotel service.

Once after the testing has been done, the problem hidden in the service system would be identified. The practicality of the service manual, operation and training manual, specifications of the information system and the tools would be observed. Thus, service engineer is able to revise the manuals owing to fit for practical use. The SOP conforming actual situation can be developed.

3.1.5 System Maintenance & Review

Once the system has been testified with no error and everything is fine, services can then be delivered. In *regular basis,* the quality of service and the performance of the system have to be reviewed. Potential problem could be analyzed by using GAP model (see Figure) and the quality service could be evaluated by SERVQUAL. If there is something wrong, review the system and make (minor) modification.

It is clear that system maintenance and review are conducted by management team in an organization. It is routine works, in daily basis, weekly basis or monthly basis. It is the only stage that customer feedbacks are actually collected. In the earlier stage of the system has been launched, review process should be done more often. Focus should be on customers and then the staff members who are involved in the service system. System modifications should be done proactively. Similar to that of system testing, maintenance and review plans should have been ready when the system has been designed. Precautions and exceptional handling procedures should also been added.

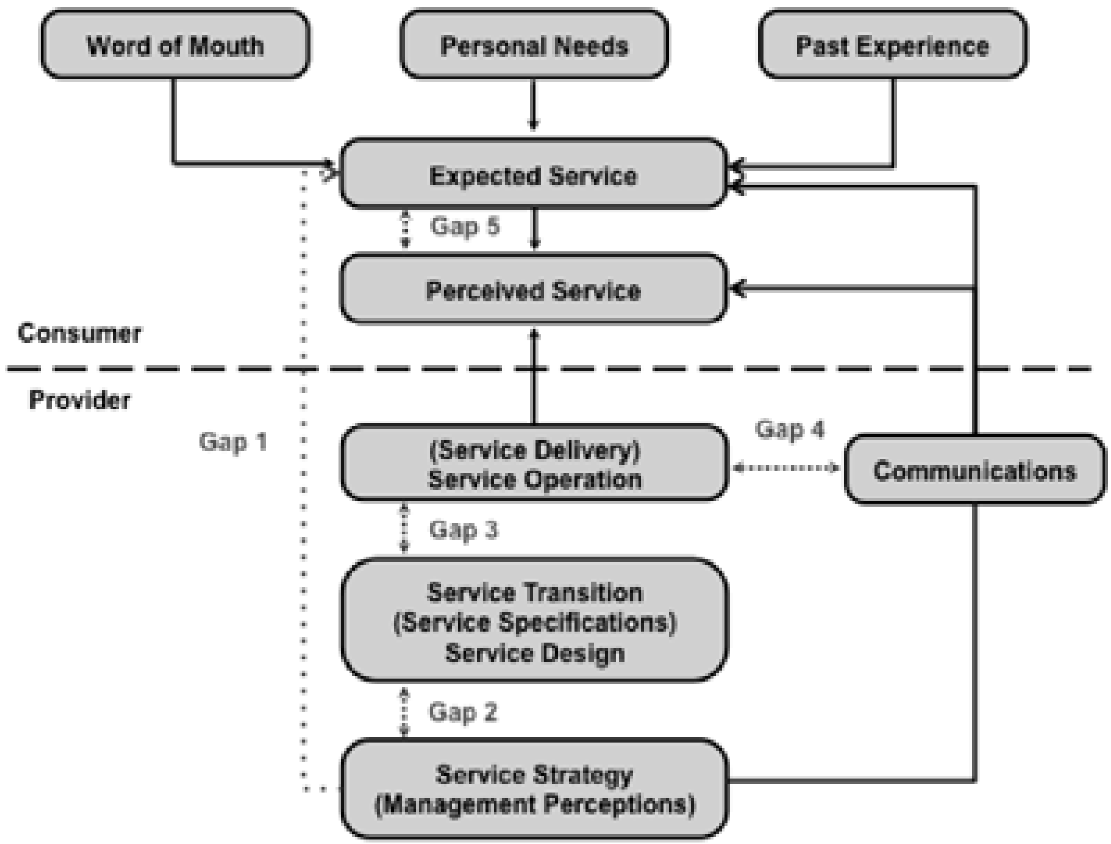


Figure 12: GAP model.

3.2 Alternative Methodologies

It is clear that our methodology on service engineering should be treated as a reference guideline, and definitely it is not universal. Other researchers and organizations have already suggested their own reference models (Arsanjani et al., 2008; Baltacioglu, Ada, Kaplan, Yurt, & Kaplan, 2007; Bitner et al., 2008; Bullinger et al., 2003; H.-M. Chen et al., 2009; Gremler, Bitner, & Zeithaml, 2012; Hara et al., 2006; Piccinelli, Zirpins, & Lamersdorf, 2003; Tien & Berg, 2003a; L.-J. (LJ) Zhang & Zhang, 2008; L.-J. Zhang, 2009). Figure 8 shows three of them (Arsanjani et al., 2008; Gremler et al., 2012; L.-J. (LJ) Zhang & Zhang, 2008) and how do they relate to each others. While their focuses have somewhat differences, the sequence of the development steps all more or less the same. However, the goals of all these frameworks are the same. It is to facilitate the development and management of a service system to a better place.

Service Eng.	IBM SOMA	Bitner Model	IEEE TSC
▪SS Analysis	▪Business modeling & transformation ▪Identification ▪Specification	▪Business strategy development or review ▪New service strategy development ▪Idea generation ▪Concept development and evaluation ▪Service design(*)	▪Consulting and strategic planning
▪SS Design	▪Realization	▪Prototyping	▪Service engagement ▪Service delivery
▪SS Implementation Training IS Implementation	▪Implementation		
▪SS Testing			
▪SS Maintain & review	▪Deployment, monitoring & management	▪Commercialization ▪Post-introduction evaluation	▪Services operation ▪Services billing ▪Services Management

Figure 13: Summary of our service engineering methodology and others.

3.3 Relation to Service Science

With the above definition on service engineering, we are able to identify clearly the similarities and differences amongst service engineering, service science and service management. Service science focuses on understanding the behaviors of a service system like an organization or a service ecosystem which consists of many organizations. By understanding, it refers to system modeling and system analysis. The behaviors could refer to the performance, the service quality, the competitiveness and the social impacts of the service system. To be science, the models have to be formal. Analysis has to be analytical. For complex service systems, extensive computer simulations have to be conducted. In this regard, theories in operations research (Badinelli, 2010; Brown et al., 2005; Gans, Koole, & Mandelbaum, 2003; Pinedo, 2008), techniques in system modeling (Demirkan & Dolk, 2013; Jennings, 1999; Kast & Rosenzweig, 1972; Liu & Tsui, 2006; Noran, 2000; OMG, 2011) and techniques in computer simulations (Bonabeau, 2002; Crowder, Robinson, Hughes, & Sim, 2012; Forrester, 1961; F.-R. Lin & Pai, 2000; Qiu, 2009) will be applied. For clarity, we call the expert who is able to handle such theoretical works the service scientist.

With reference to the service engineering framework, large amount of works to be done in the stages of analysis and design are essentially the same as the works to be done in service science. Except that attaining optimal design is not a goal in service science. Note that the scope of service science is not limited to the analysis of service systems within an organization. All kind of service systems are interested to the service scientists.

3.3 Relation to Service Management

Service management refers to managing the processes (service delivery process and other supporting processes), the people and the tools within an organization in order to deliver quality services/products to the end customers and managing the services for managing the usage and the development of the services. Precisely, two types of management activities are of primary concerns: (i) the management of the operations regarding the delivery of the service and the management of the service (or experience) quality; (ii) the management of the development of the service delivery process. For clarity, we call the manager who handles the first type of management activities the service operation manager (SOM). While the manager who handles the second type of management activities is called the service development manager (SDM).

Clearly, the first type of activities stem on the issue service operation management assuming that both the operational procedure and the quality measures have been defined. With reference to the service engineering framework, they are the activities to be conducted in the maintenance and review stage. Management processes include order fulfillment, human resource management, supply chain management, customer relationship management, marketing and financing, and information management. SOM would have to work closely with the operational staffs and follow the pre-defined procedure to deliver high quality service to the customers.

The second type of activities refers to the activities to be conducted during the service system engineering framework, in which the first type of activities is defined. SDM would have to work closely with the service engineer to ensure a practical and accountable service deliver process. The organization has been structured or restructured to allocate resource to support the service. In the implementation stage, SDM has to track the progress and make sure the implementation can meet the schedule. The performance of the service system fulfils all the performance measures being set in the design stage.

4. SYSTEMS MODELING

The heart of service engineering is on the modeling of a service system. It is what the service scientists, the service engineers and the service development managers need to work out at the stages of system analysis and system design. Clearly, no single model is able to express well the overall picture of a service system. Diagrams, documents (e.g. operational manual) and languages (programming languages or mathematical equations) are all useful tools for describing the detail specifications of the components and the interfaces (conversations and message passing) amongst components. A component can be a single person or a single piece of program. The importance of such models is that analysts (system modelers or system designers whatever we call them) are able to describe the service system with *no ambiguity*. It turns out to be a very challenge issue. It is because system modeling requires talent to trade-off between complexity versus readability, as well as formality versus informality of the models.

Service blueprint (Bitner et al., 2008; Shostack, 1982, 1984) is an example of informal model for presenting a service system. It is easy for the management people to outline their ideas. However, there are limitations inherent service blueprints. First, service blueprint is a labor intensive model. For machine intensive service systems like cloud services and telecom services, service blueprint would not be easily defined. Second, definitions on the processes, interactions amongst customers, employees and the support processes are normally stated qualitatively. It could lead to misspecification and eventually an erroneous service system is built. Third, information system in a service blueprint is treated as a supporting process and its operations are defined qualitatively. In the end, it generates yet another gap between the management team and the development team on the requirement of the information system. By the same reason, analysis on the service system based on service blueprint can best be accomplished by quantitative approach.

Formal Models like OMG Unified Modeling Language (UML) OMG Web Service Business Process Execution Language (WSBPEL) OMG Business Process Modeling Notation (BPMN) and IDEF (Integration Definition) are definitely useful in system modeling[7]. Their main purposes are to define a vigorous model for a system with no ambiguity. Logical models and mathematical models are defined for a service

[7] If you search Wikipedia "Model Language", you will find a lot more formal models that are particularly designed for system modeling. Here, we just name a few of them.

system. Moreover, agent-based or autonomous-oriented modeling could also be applied to model agents (software agents or people) who are involved in humanized works. With these models, analysis could be accomplished theoretically (for instance by queuing theory and scheduling theory) and computer simulations can be done to anticipate any exceptional behaviors might appear. Moreover, the waiting time, the time to deliver and the operation cost can be estimated. The model can be validated and thus the optimal design on the service system can be achieved. If measure on customer experience is defined, the satisfactory level could be anticipated.

List of testing cases for system testing can be complied. Exceptional handling procedures can be defined. It is clear that the aforementioned formal models are just a few examples. There are many others available. To understand both informal and formal models, and transform an informal model to a formal model turn out to be one major task that a service engineer needs to accomplish. It is not an easy task as management professionals and engineering professionals always focus on different types of languages. In service management, as Bitner et al mentioned, UML is a complicated modeling language. Software engineers would very much reply on UML as it can model a system with no ambiguity. To this end, we would like to suggest a list of core diagrams that both management professionals and service engineers should understand with no excuse. They are business model, service blueprint, organization chart, sequence diagram, use case diagram, and business component diagram.

Figure 8 to 10 show an example of dining service. In a restaurant, the generic service is dining. Customer can reserve a table via phone call. The front desk will then check the availability and confirm the reservation. In the day of dining, the front desk will lead the customers to the table that has been cleaned and tableware is ready. Menu and water are served. Once after the customers have placed the order, the kitchen will make the food and waiters (or waitresses) serve the cuisines. After having the delicious dinner, the customer checks either by cash or credit card. The waiter (or the waitress) will issue the receipt and then the front desk waiter (or waitress) will clean the table and ready the tableware for another customer. To detail the workflow of this dining experience, the blueprint, sequence diagrams and use-case diagram could be used.

The business model gives the conceptual level of the service provided by the restaurant. The use-case diagram shows the persons who are involved in delivery of the dining service. Blueprint states clearly the step-by-step how a dinner would get a quality service. Besides, it states clearly what the front-desk waiter (waitress) and chefs have to do and when they have to do. Te sequence diagram lays the very foundation on the roles and responsibilities of each person who is involved in the process and when they have to be involved. Finally, the organization chart can tell how those jobs are systematically grouped together in a form of business components (service units). For sure, information system provides important process supporting the dining service. In this regard, the functionalities of the information system and the architecture of it have to be clearly defined in a form like the diagrams for program architecture and system architecture.

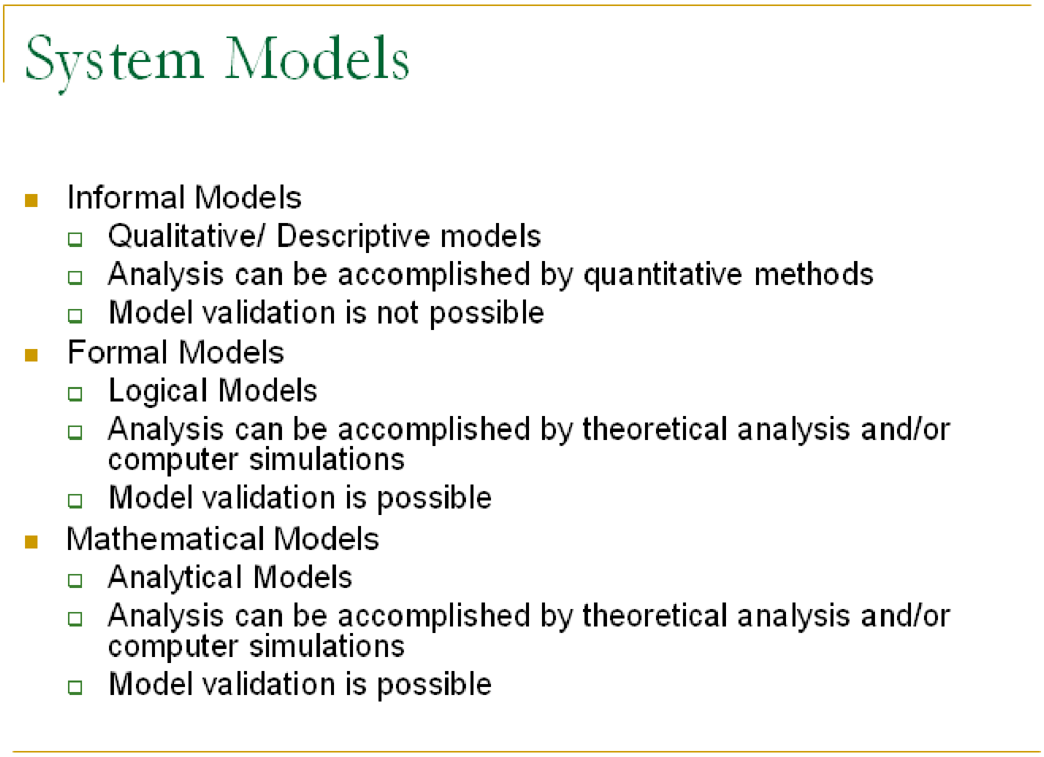


Figure 14: Types of system models.

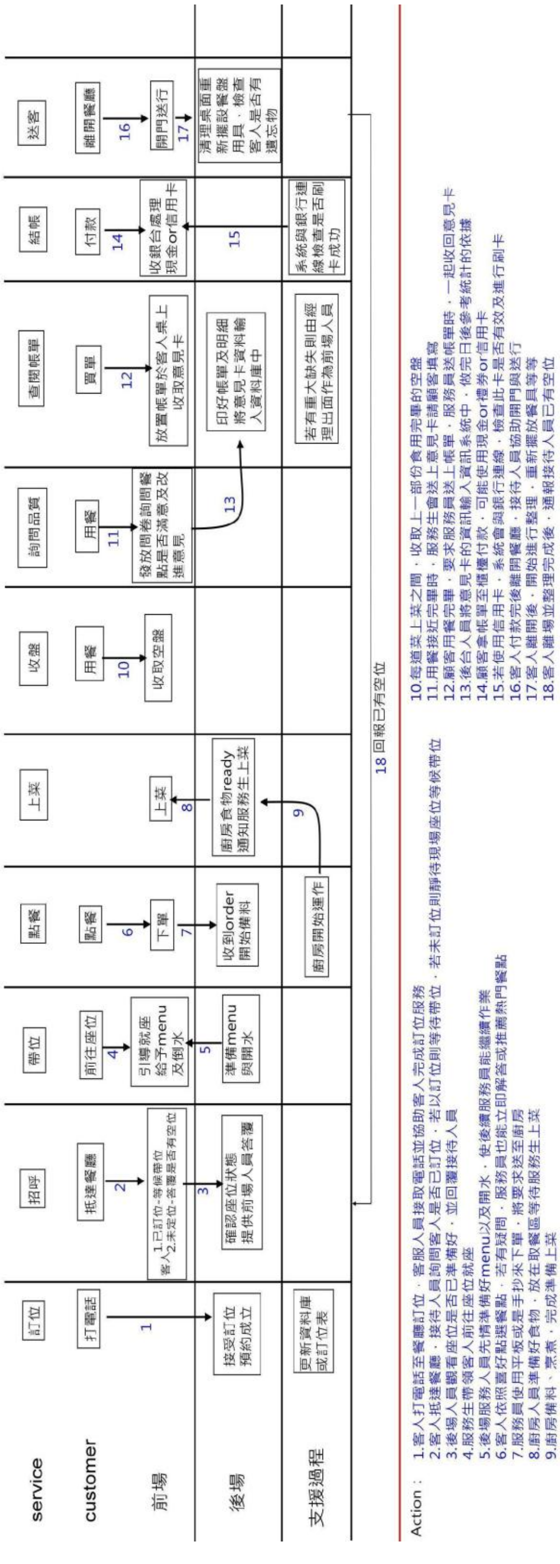


Figure 15: Blueprint of dining service.

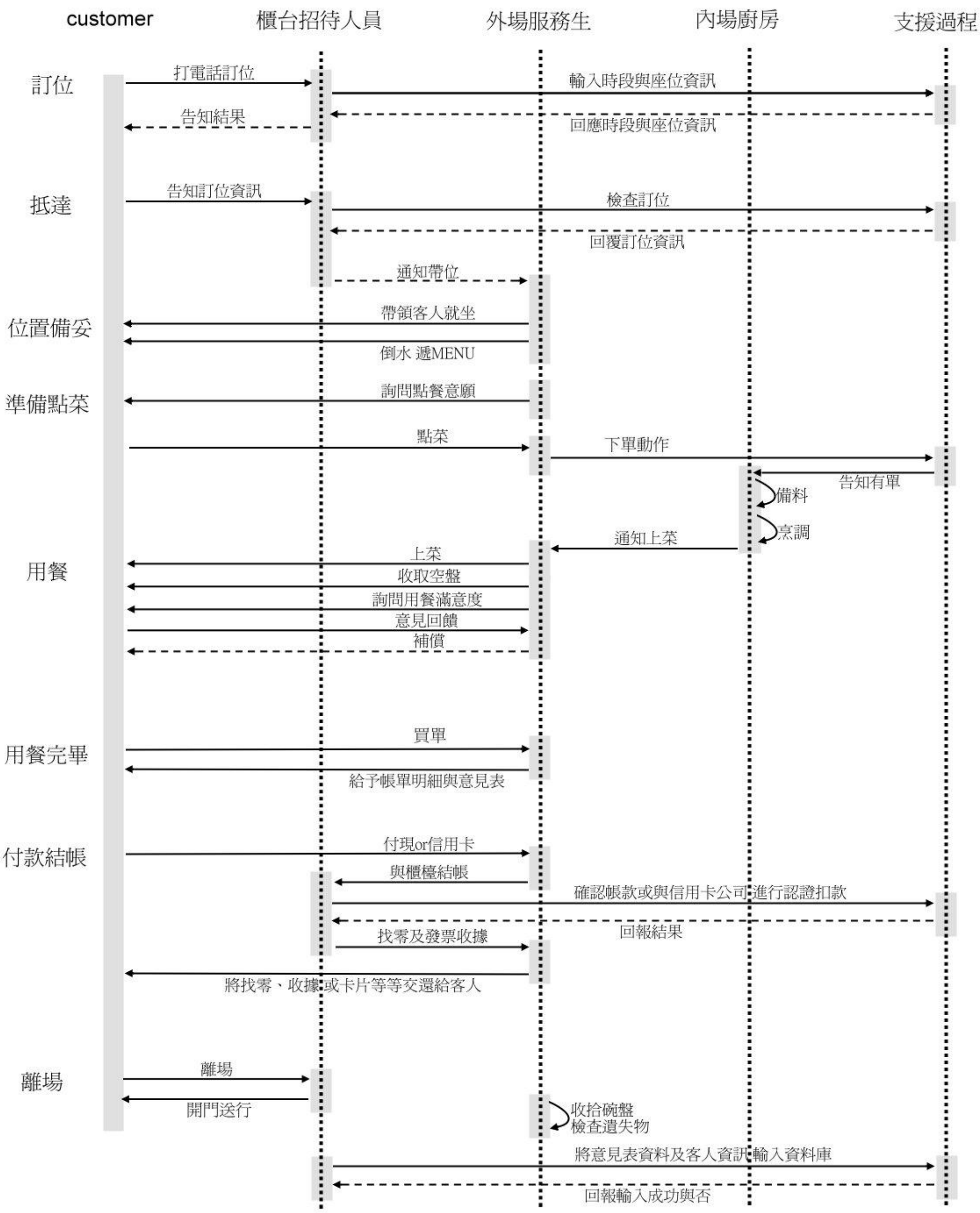


Figure 16: Sequence diagram of dining service

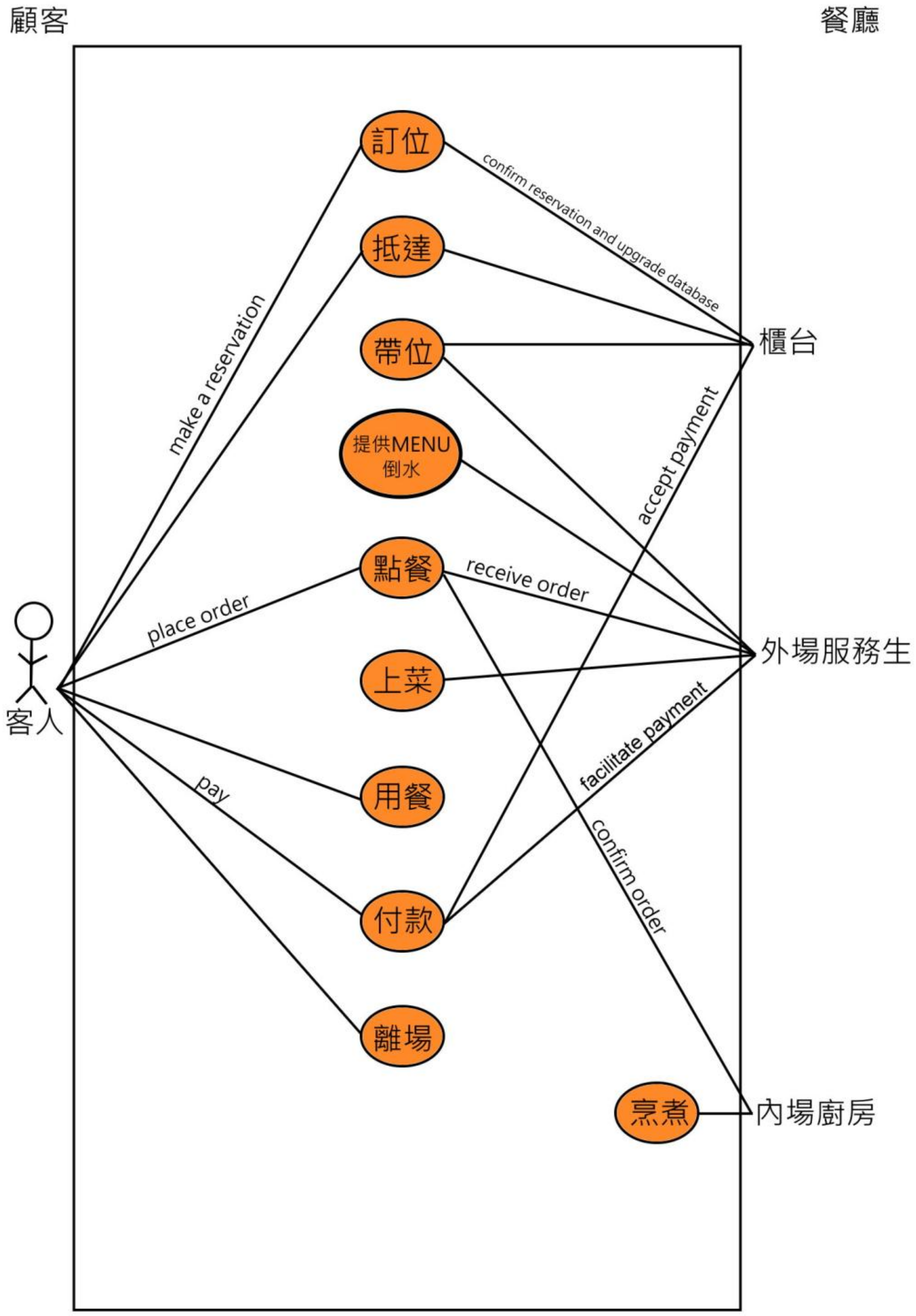


Figure 16: Use case diagram of a dining service.

4.1 Use Case Diagram

Many development processes that use UML advocate that the system development should start with use case modeling to define the functional requirements on the system. A use case describes a specific usage of the system by one or more actors. An actor is a role that a user or another system has. The objective of use case modeling is to identify and describe all the use cases that the actors require from the system. Actors and use cases in use case diagram are presented like Figure 3 in the use case diagrams.

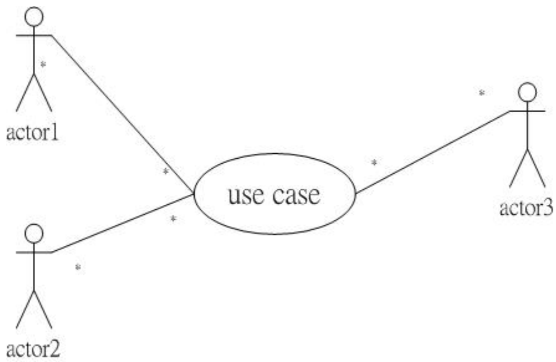


Figure 17: The example of use case diagram.

4.2 Service Blueprint

The service blueprint divides the actions into four kinds of types that are customer actions, onstage actions, backstage actions and support actions. By the definition, onstage actions include all the actions that interact with customers directly face to face. Backstage actions include all the actions that interact with customers directly by phone or other ways. The support actions include IT supports and the actions interact without customers like information system and product produce. In the service blueprint, we use the line with arrow to present the service deliver process between these stages (Figure 4).

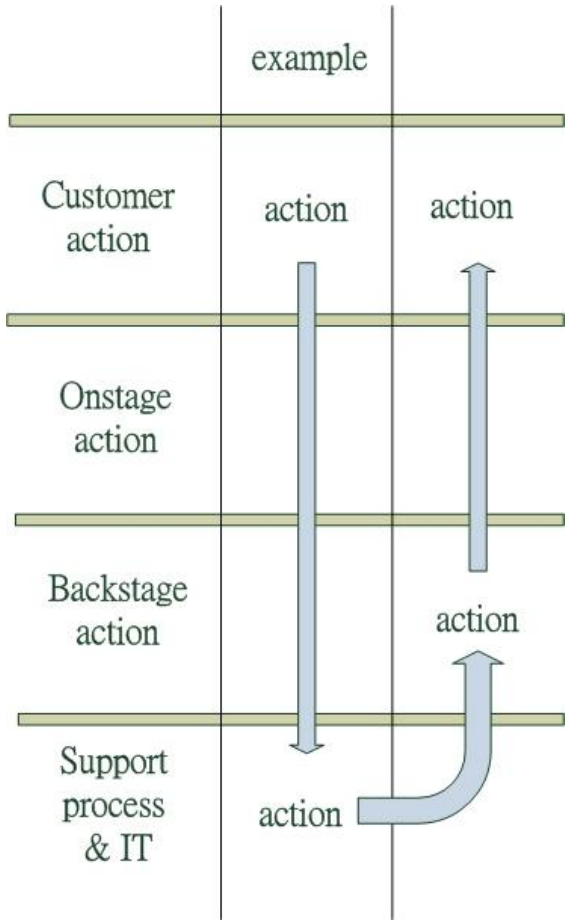


Figure 18: The example of service blueprint.

4.3 Sequence Diagram

A sequence diagram at least has these kinds of factors that are role, lifeline, activity and message. We use the real line with the arrow to present the message sending, and use the dashed line to mean the message response (Figure 5).The best advantage of a sequence diagram is that a sequence diagram can present the switch messages step by step along the lifeline. Though the sequence diagram, engineers can conceive how to switch messages between each role. Because of lifeline, sequence diagram can present the order of activities.

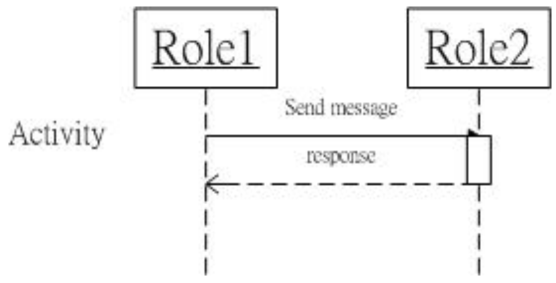


Figure 19: The example of sequence diagram.

4.4 Component Diagram

Component diagrams emphasize two point of the system, the interface of each component and the dependency of components. Engineer can use component diagram to present the existed component in the systems, the interface of each component, the relevance between components, and classify the minor unit and combine it as a sub-system (Figure 6).

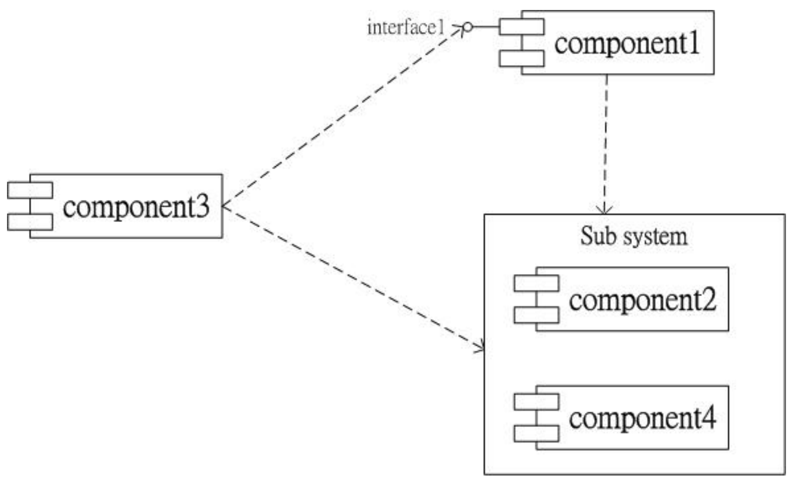


Figure 20: The example of sequence diagram.

4.5 Organizational Chart and SOP

Organizational chart shows the structure of an organization and the relations between employee, department and organization. Standard operating procedure (SOP) id designed to execute complex procedure in the limited time. SOP can save time and resource, and lead the quality stably.

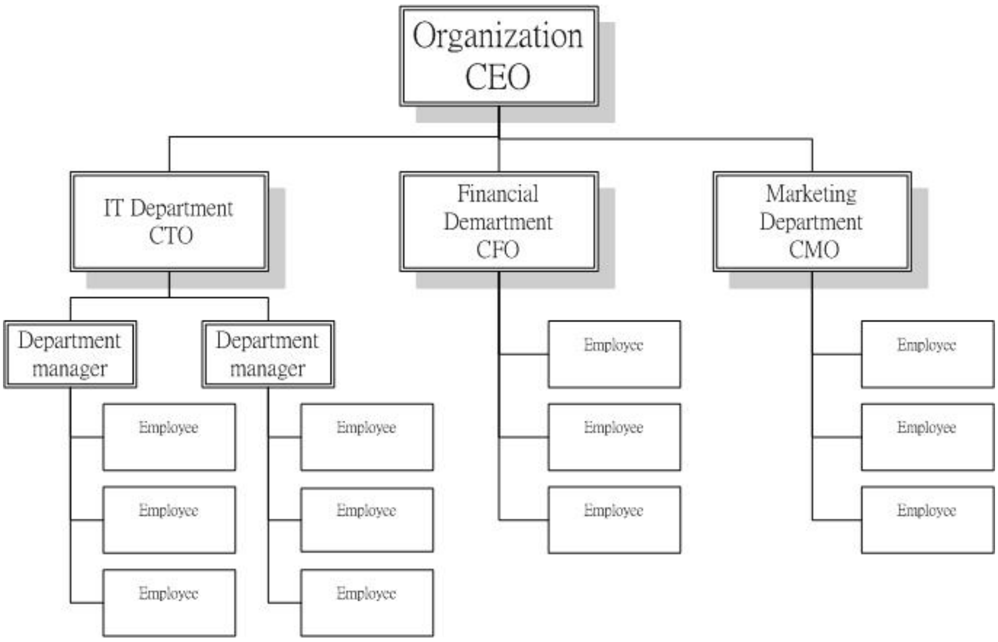


Figure 21: The example of organizational chart.

4.6 Use of the Models in SSE

We use flow chart diagram to describe designing process step by step and give an example as a home delivery service added in a hypermarket. Figure 3 shows these steps.

Step 1:

Describe the functions and the participation units by use case diagram (Figure 4). Here we use the concept of agent base. Participations can be a people, a tool, an information system or complex of these.

Step 2:

Describe the detail actions of each function, classify the actions to each stage and describe the order of each action (Figure 5). Service blueprint and use case diagram is for manager viewing the function arrangement and checking the execution procedure easily.

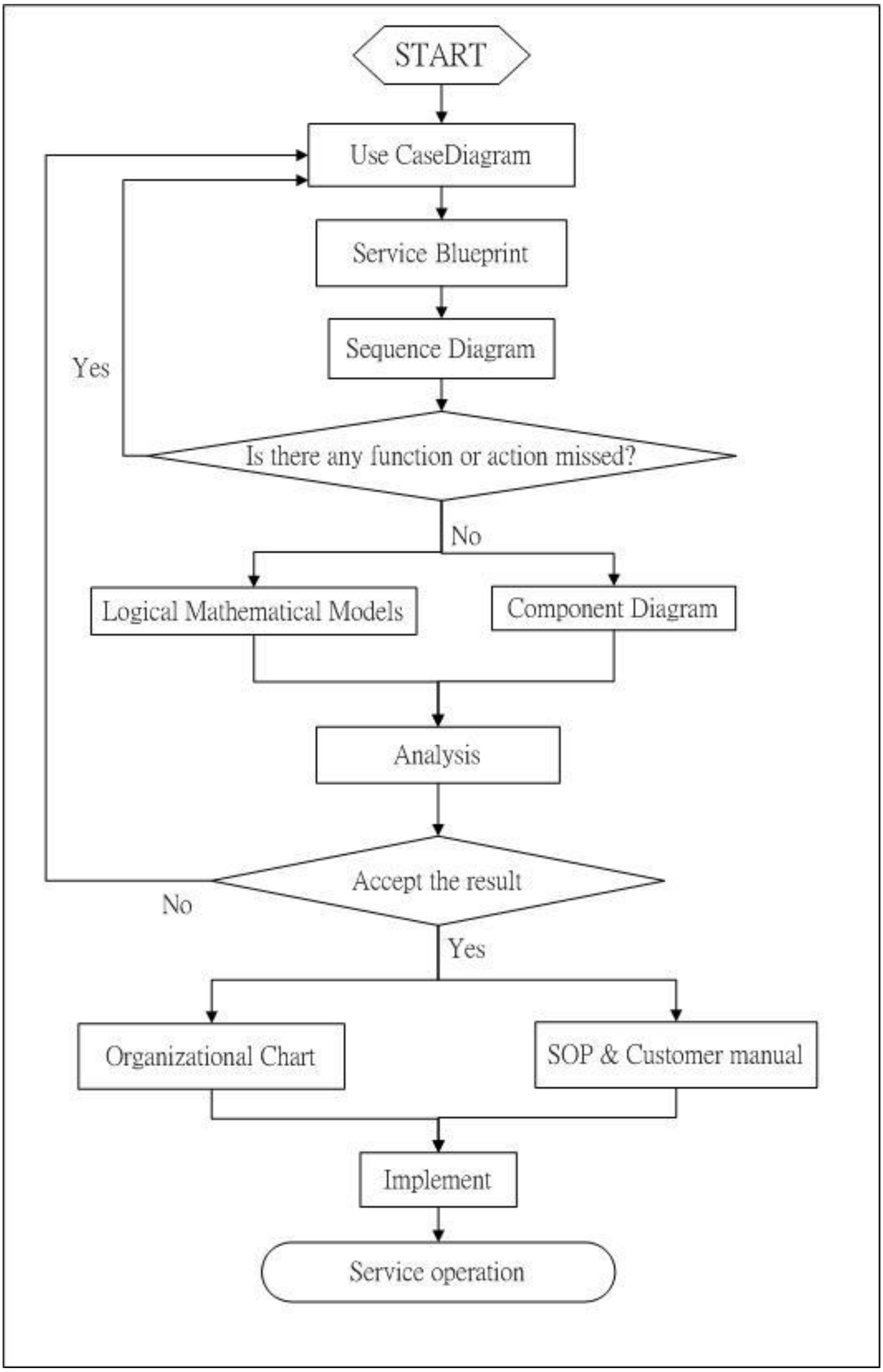


Figure 22: Use of the models in service system engineering.

Step 3:

Sequence diagram shows all participation units, functions, and actions. And link the functions and actions by the time line of each unit (Figure 6, 7). It is easier to let programmers to understand all the operation procedure and the role of each information system. Furthermore, sequence diagram can help service engineer to check whether there is any action be missed or not. If there is any action missed, the operation procedure which presented in sequence diagram cannot be completed.

Step 4:

Check if there is any function or action missed in the prior steps.

Step 5:

Service engineer can use component diagram (Figure 8) to classify the minor unit and combine it as a subsystem. Component diagram also can help to design organization chart. Logical mathematical model defined time consuming of each action, rational customer waiting time and some types of cost etc. These model or value will be used in the analysis step.

Step 6:

There are two types of analysis, mathematical analysis and computer simulation. Small service system with less uncertainty value can use the mathematical analysis to analysis. Larger service system and the system with lots of uncertainty value like ambulance assignment system have to use computer simulation to help analysis.

Step 7:

If the analysis result cannot be accepted, service engineer have to return to step 1 to assess and adjust the models.

Step 8:

After analyzing, service engineer can design SOPs for operational staff and customer manual by extracting procedures from sequence diagram (Figure 9) and design organizational chart for manager by component diagram (Figure 10).

Step 9:

It comes to implement step. Everything includes tools and information systems are built or purchased. Operational staffs are trained.

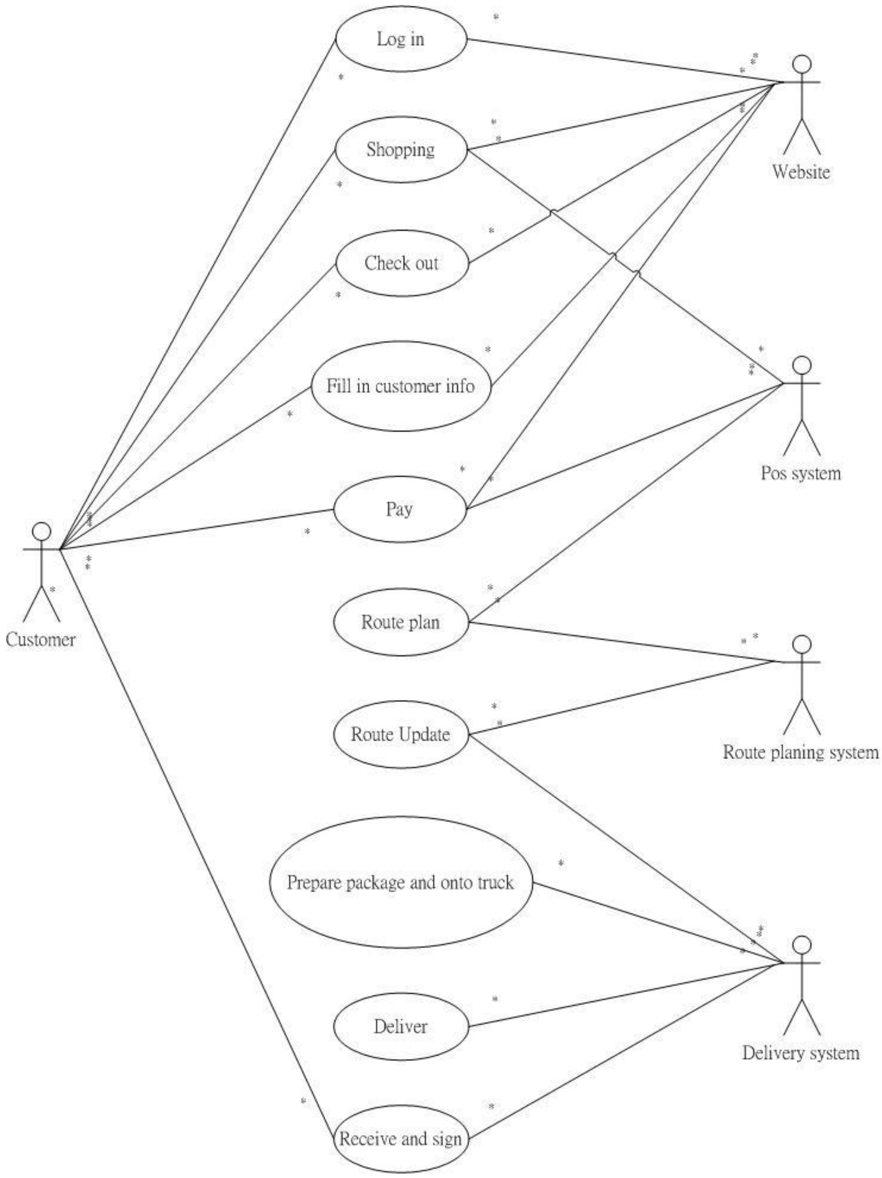


Figure 23: Use case diagram for a hypermarket.

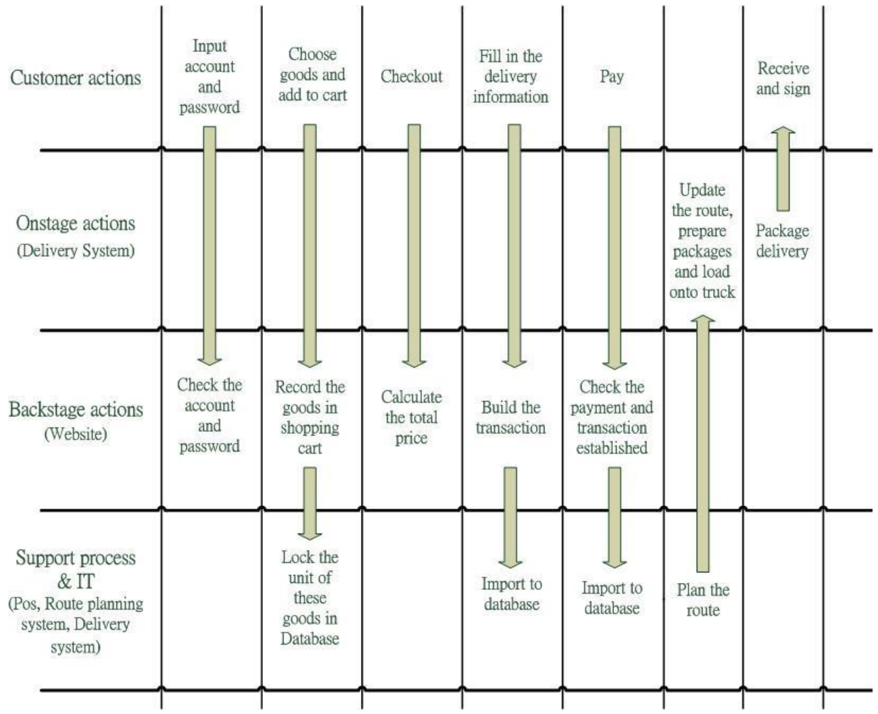


Figure 24: Service blueprint for a hypermarket.

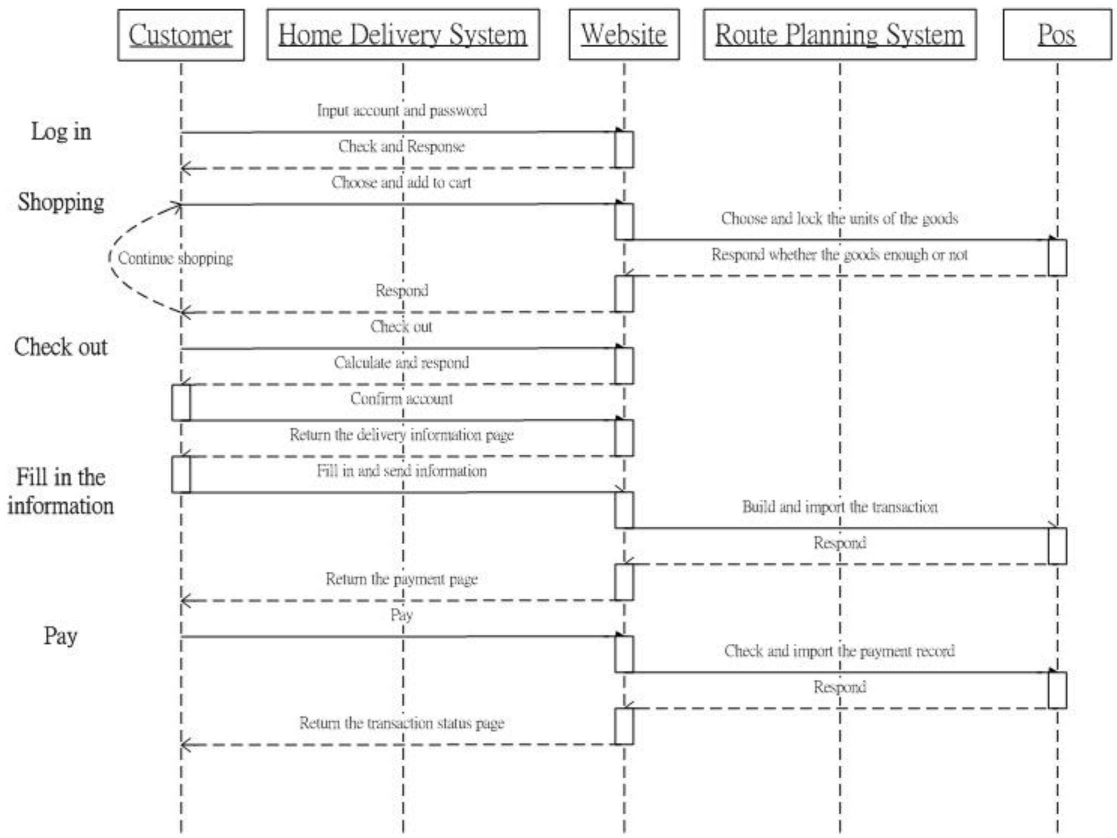


Figure 25: Sequence diagram for a hypermarket.

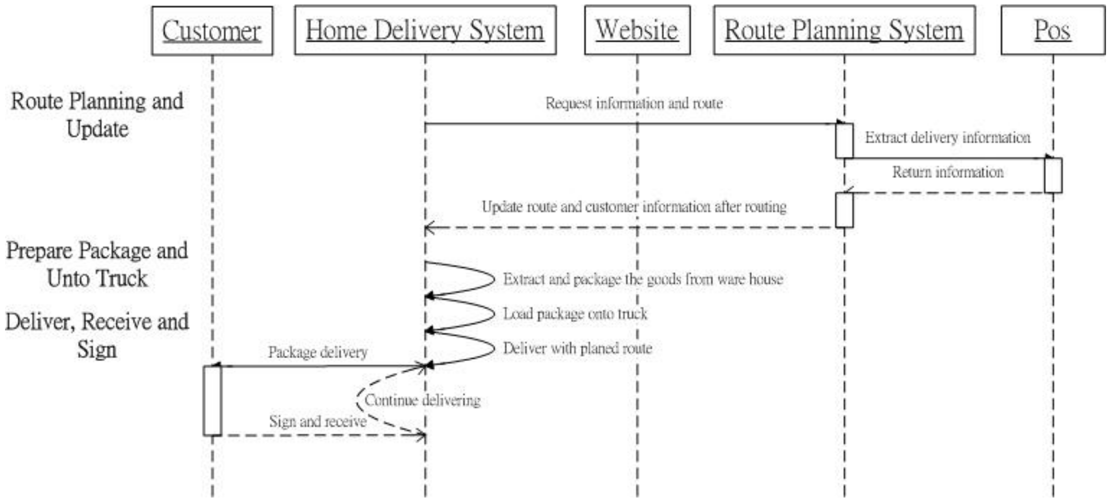


Figure 26: Sequence diagram for a hypermarket.

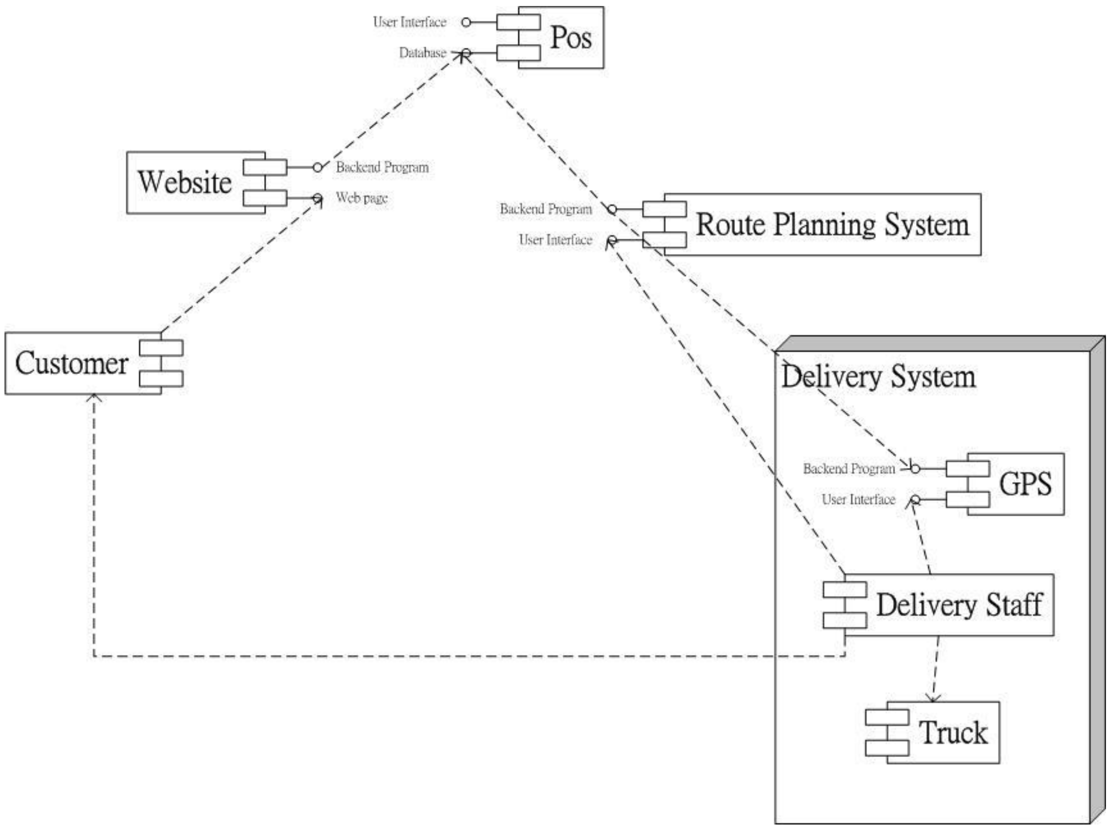


Figure 27: Component diagram for a hypermarket.

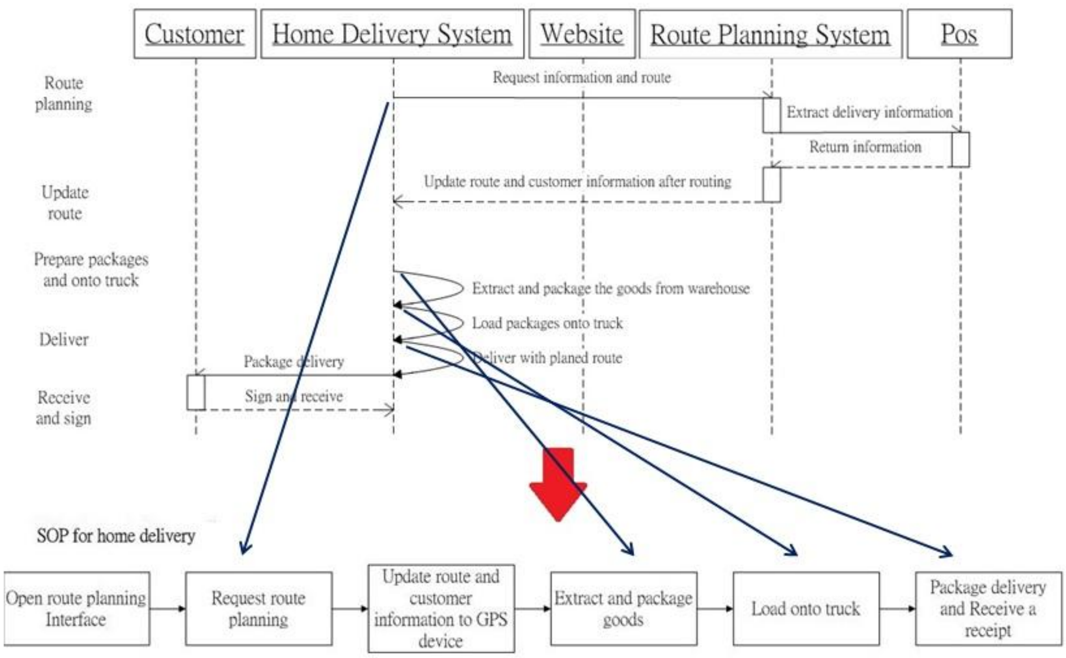


Figure 28: SOP extracted from sequence diagram for a hypermarket.

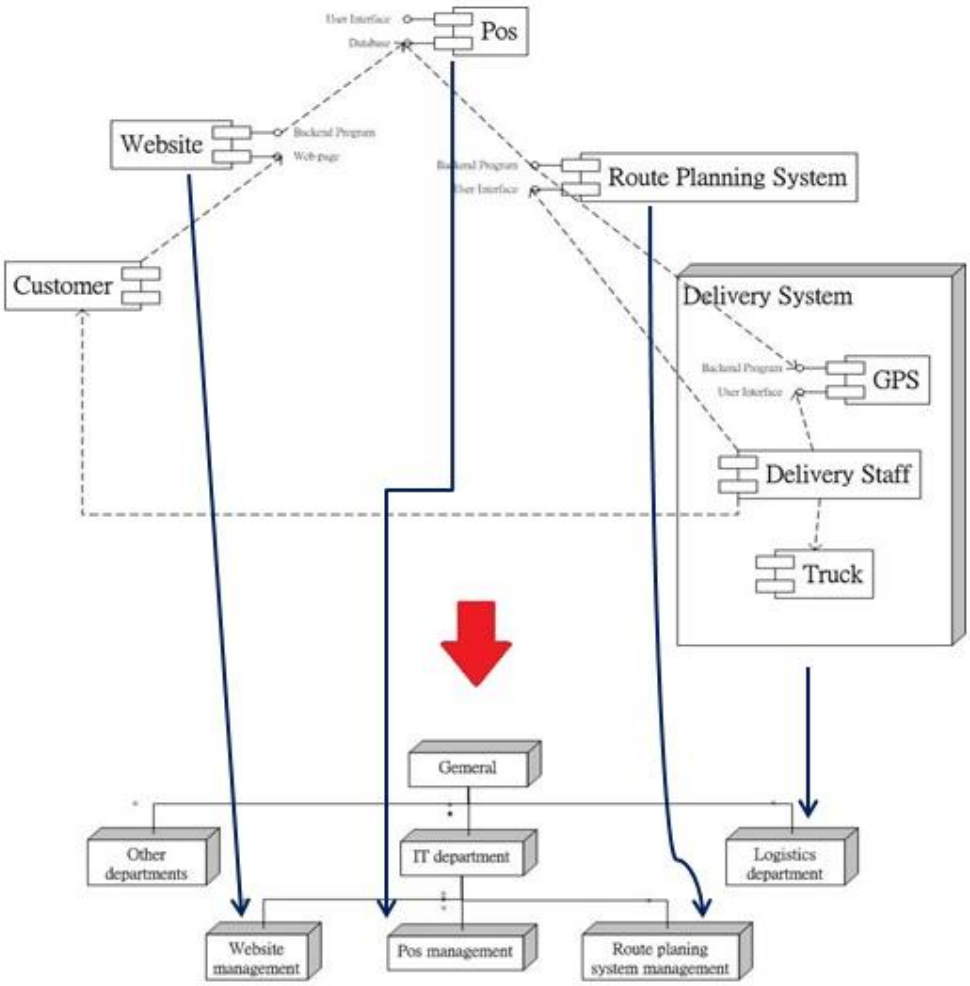


Figure 29: Organizational chart extracted from component diagram for a hypermarket.

From these nine steps, we can know that managers have to require the knowledge of service blueprint and use case diagram to understand the function arrangement and execution procedures. Managers also have to know the organizational chart to design the department of their company. IT developers have to know the sequence diagram to understand the operation procedure and the role of each information system. Operational staffs have to know SOP. Service engineers have to know all the models mentioned in nine steps to design the service system and bridge the gap between each role to help communication. Table 1 shows the model knowledge requirement of each role.

Table1. The required model knowledge of each role

	Manager	**IS Developer**	**Operation Staff**	**Service Engineer**
Use Case Diagram	+ + + +	+ + + +	+ +	+ + + +
Service Blueprint	+ + + +	+ + +	+ + +	+ + + +
Sequence Diagram	+ +	+ + + +		+ + + +
Component Diagram		+ + + +		+ + + +
Organizational Chart	+ + + +	+ +	+ + +	+ + + +
SOP	+ + + +	+ +	+ + +	+ + + +

5. CASE STUDY: DonZ SERVICES

5.1 Service Offer

DonZ is a startup IT firm that builds service systems, provides online services and selling physical products. ‘Surprise’ is one of its services. It provides a platform and some themes like wedding, Valentines’ day and birthday for users to design a webpage. The webpage includes album, video and text. Users can upload the media and design the webpage by the platform. After designing the webpage, users can purchase, choose and design the QR code product like stickers, cards or other goods. “DonZ” will produce and deliver the products to users after users paying. When the recipient receive the goods include the QR code, they can read the webpage by scanning QR code in real time.

In DonZ, there are four permanent staffs, including a manager, a service engineer and two programmers. The team cooperates by the platform Trello, and communicates and coordinate base on these models. We revise the models every time when the functions and procedures of surprise service have been changed. Figure 17 shows the processes of cooperate on the Trello.

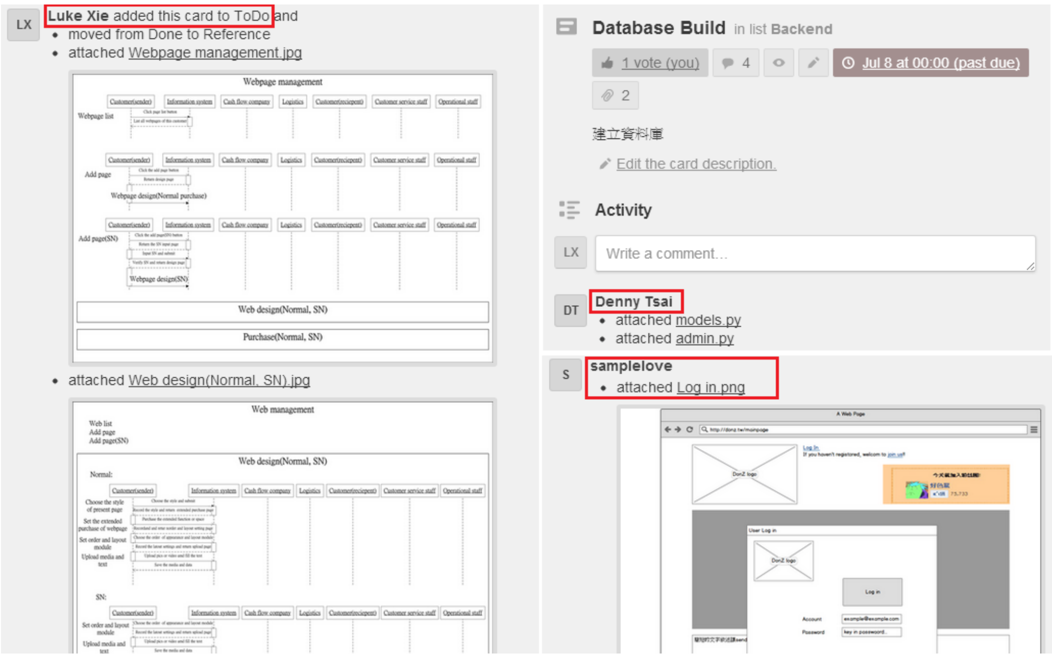


Figure 30: Cooperative design via Trello

5.2 Modeling Surprise Service

5.2.1 Use Case Diagram for Surprise Service

First, we describe the functions and the related participations by use case diagram (Figure.17). We divide all functions into four sets that are webpage management, webpage design, purchase and other. Functions about webpage management are webpage list, add page, add page (SN). Functions about webpage design are choose style, set extended purchase, set layout and upload media. Functions about purchase are the functions choose product format, setting encryption, check out and input delivery information and pay. Other functions are register, log in, read the webpage, produce, deliver and customer service. After defining functions, we have to define the related participations that can be departments, operational staffs, customers or information systems. Here we define the participations that are customers (sender and recipients), an information system, a cash flow company, operational staffs, logistics, and customer service staffs. The last step, we have to link each function to related participations.

Actually, IS engineers have been able to produce the wireframe. For example, the official page should include two buttons about log in and register (Figure.18). After customer log in, the log in button has to transform to webpage management button.

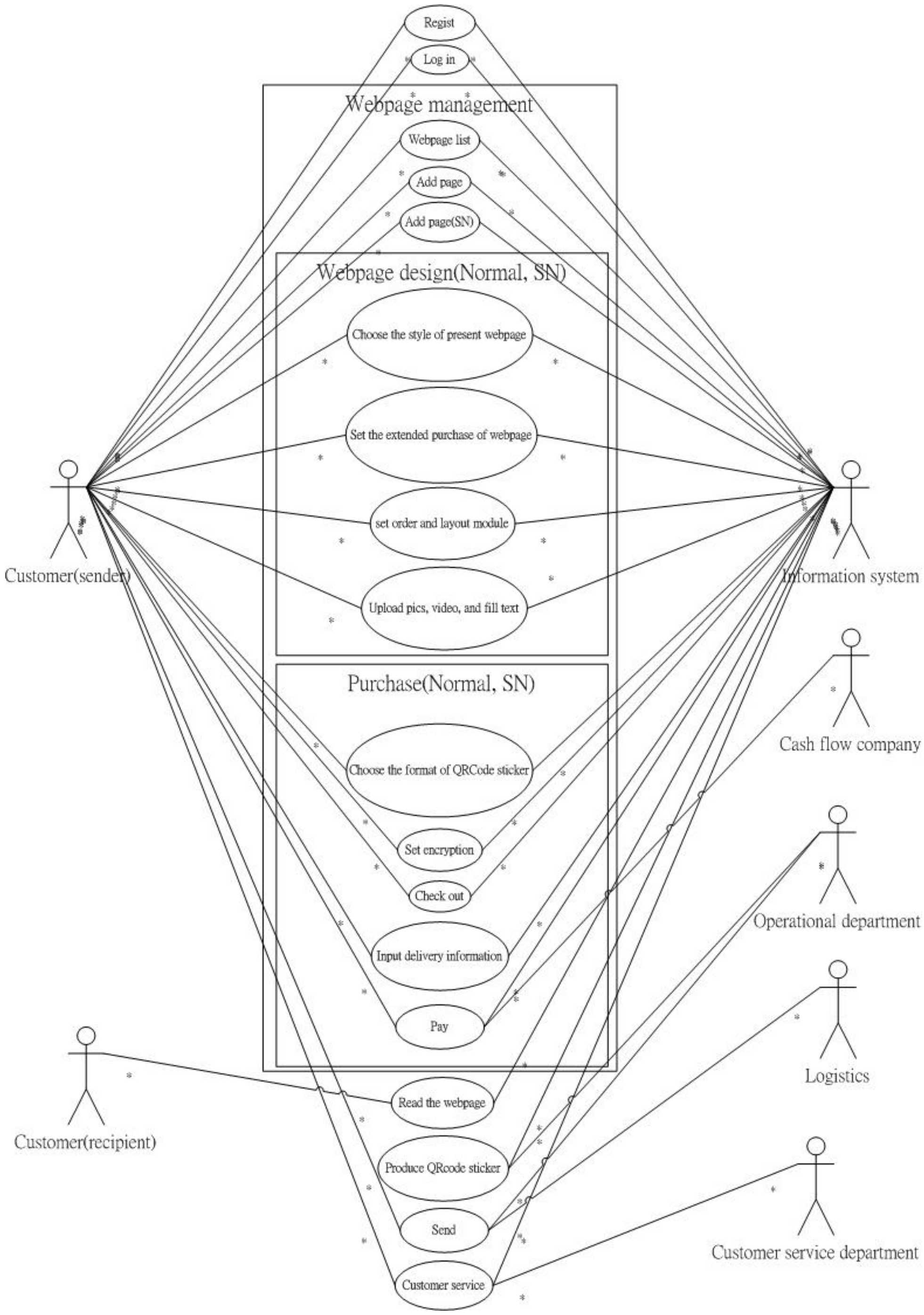


Figure 31: Use case diagram for surprise service

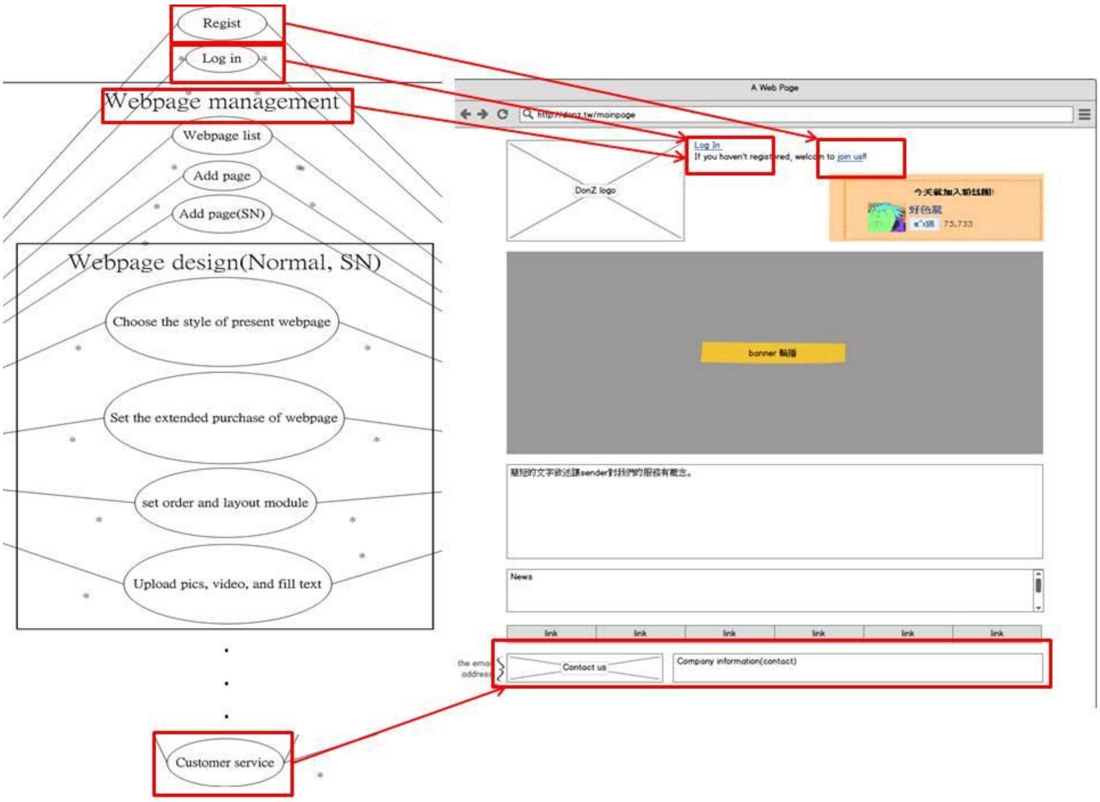


Figure 32: Use case diagram to wire frame

5.2.2 Service Blueprint for Surprise Service

Second, we defined the service delivery process of each function by service blueprint (Figure 19, 20). In this case**,** logistics deliver is onstage action, customer service is backstage action, and cash flow procedure and product produce by operational staffs are support and IT actions.

Manager can design the probable deliver procedure of each function by service blueprint. Service blueprint will become a reference for service engineer to produce sequence diagram. Moreover, because the action of onstage, backstage and support, and their participations are clearly defined, managers can refer to service blueprint to allocate the resource. In this case, there is only logistic participate in the onstage action. And only customer service department participate in the backstage action. The actions about support process and IT take a large portion. From the blueprint, it is easier to know that the allocation of budget should be emphasized in the parts of information system department to design the web and maintain the management system, operating department to produce products efficiently, and the customer service department to receive the opinions and handle the exception problem.

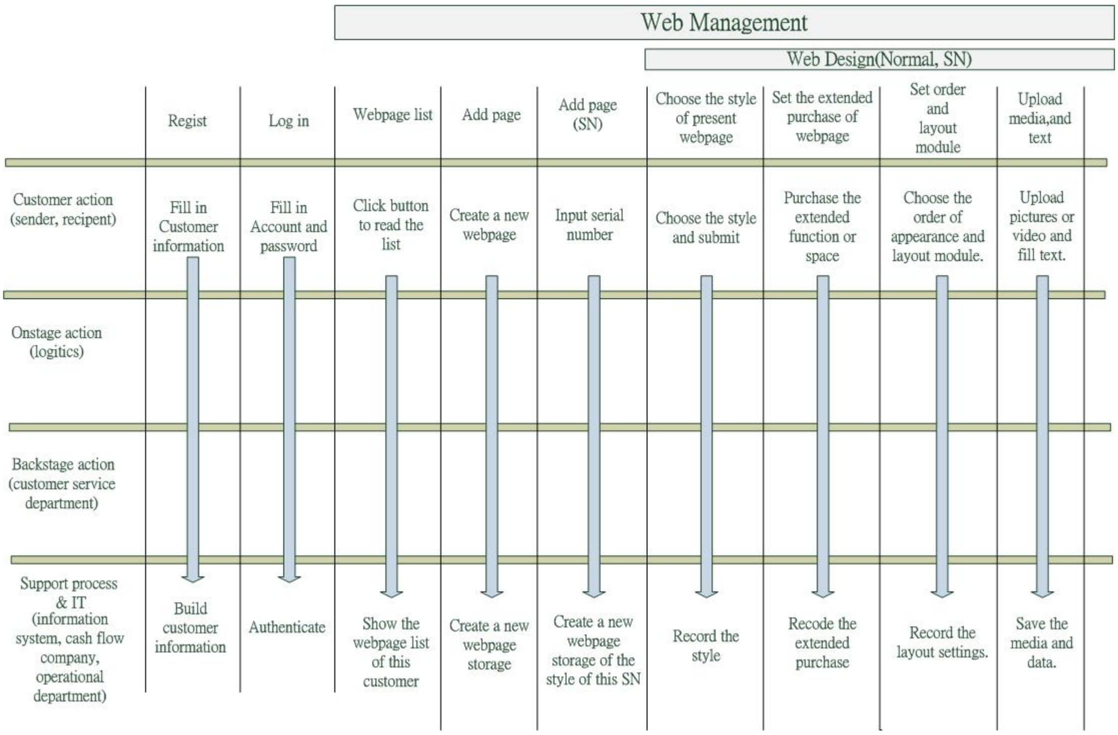


Figure 33: Service blueprint for surprise service

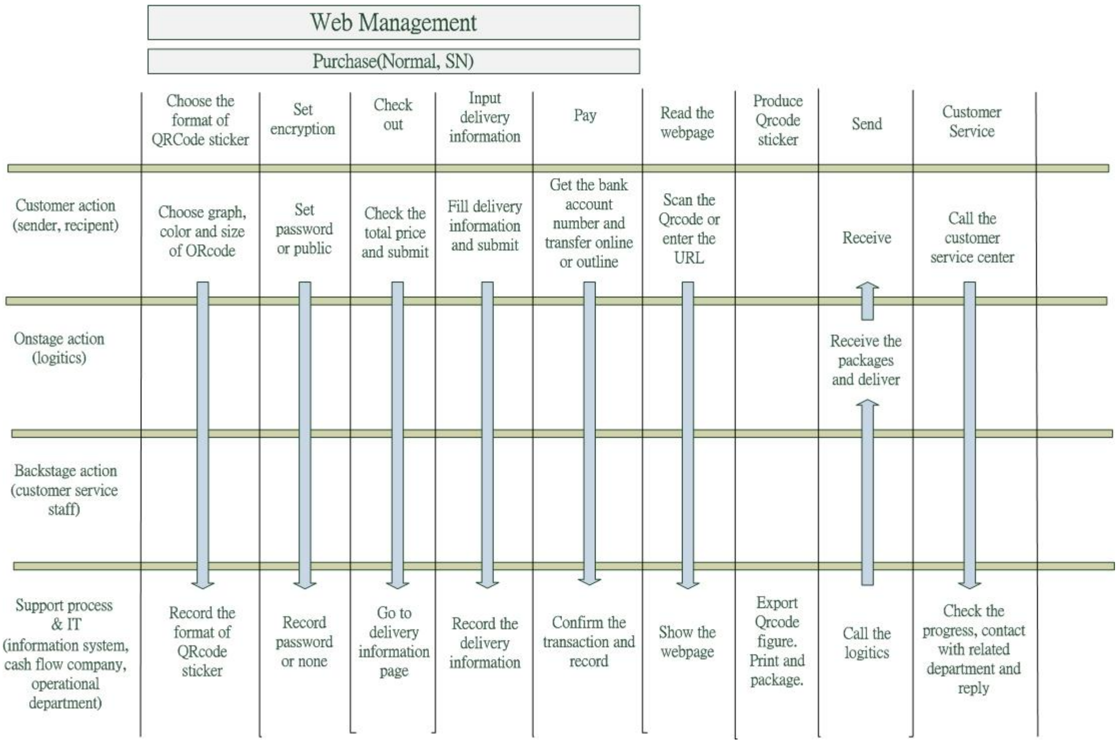


Figure 34: Service blueprint for surprise service.

5.2.3 Sequence Diagram for Surprise Service

After designing the service blueprint, service engineers have to design the sequence diagrams. In the sequence diagrams, the related functions are connected in accordance with the time lines. The procedures of each function could be elaborated in more detail. Figure 21-25 are the sequence diagrams for surprise service. We design the diagrams for each situation. From the sequence diagrams, IT engineers can clearly know the service operating processes and system requirement, and designing th backend programs and database.

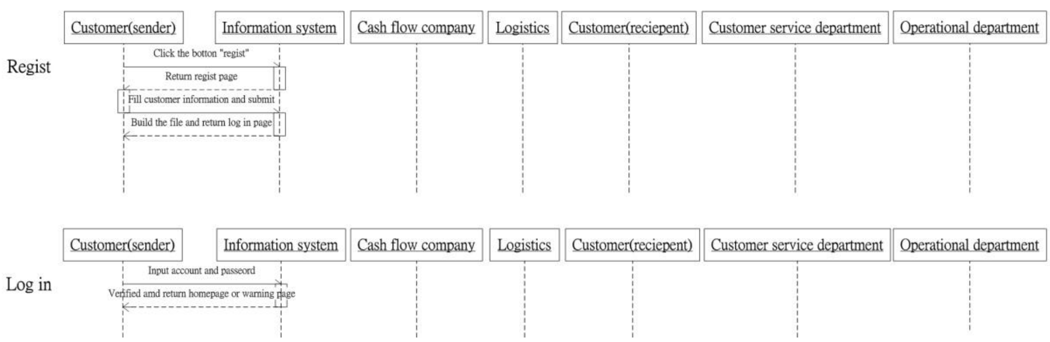


Figure 35: Sequence diagram for register and log in.

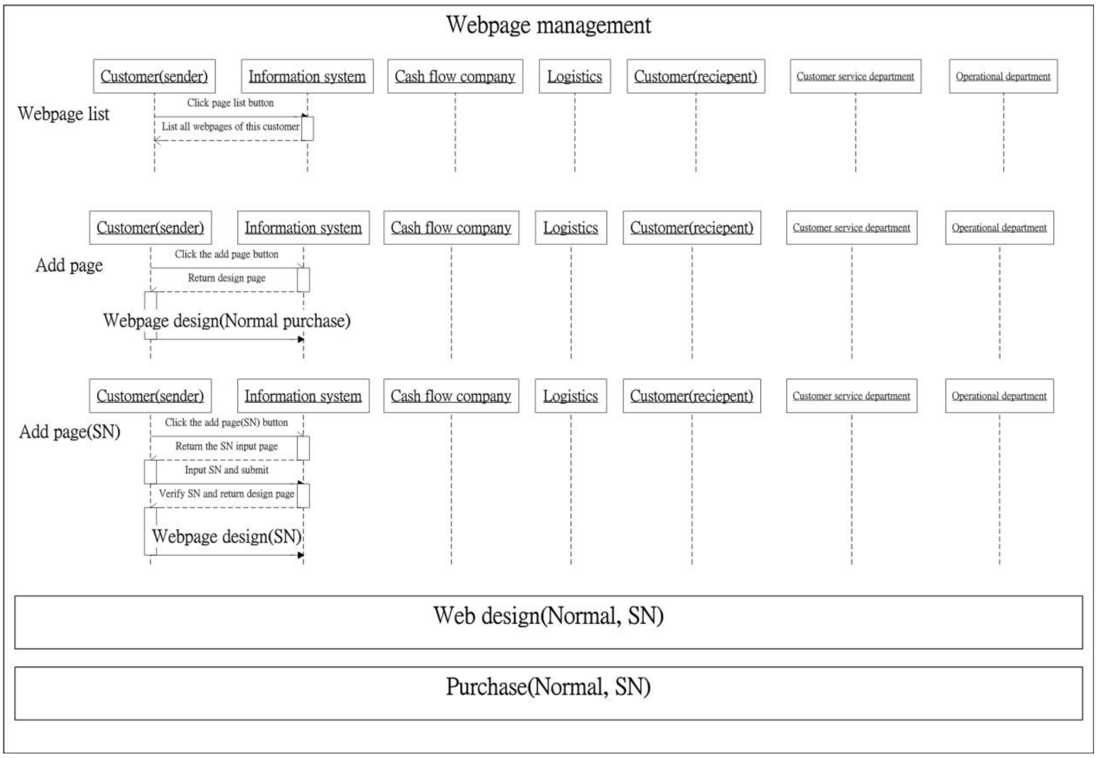


Figure 36: Sequence diagram for webpage management.

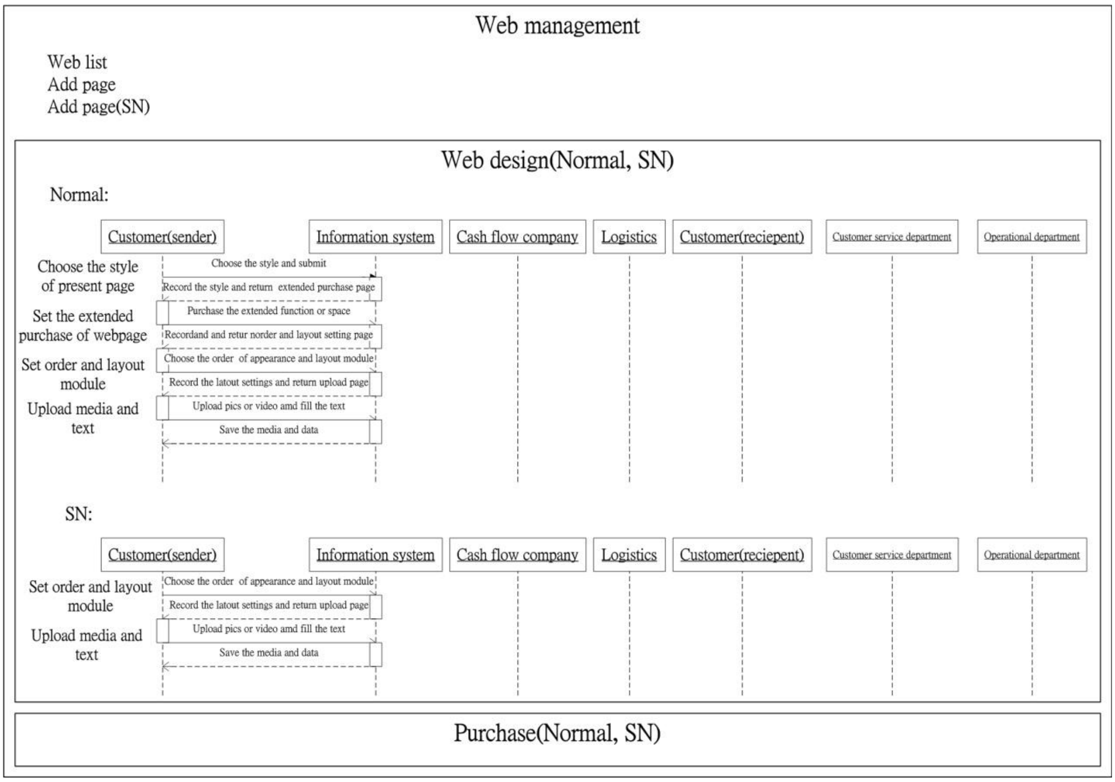


Figure 37: Sequence diagram for web design.

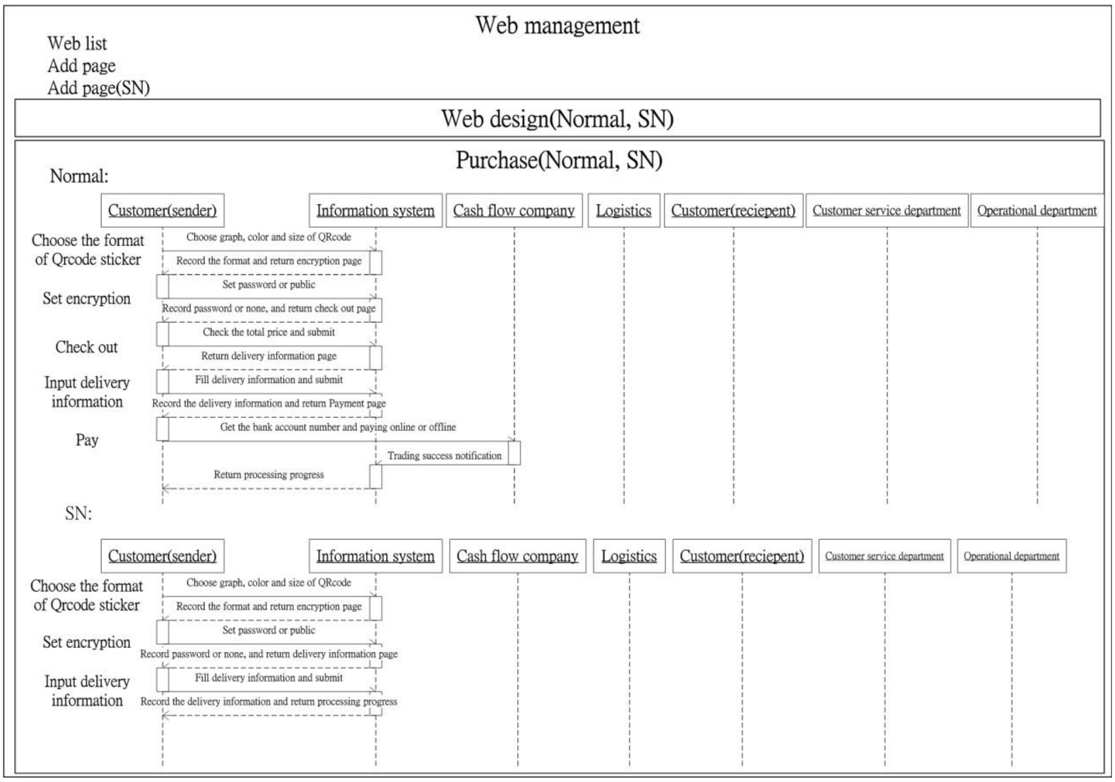


Figure 38: Sequence diagram for purchase.

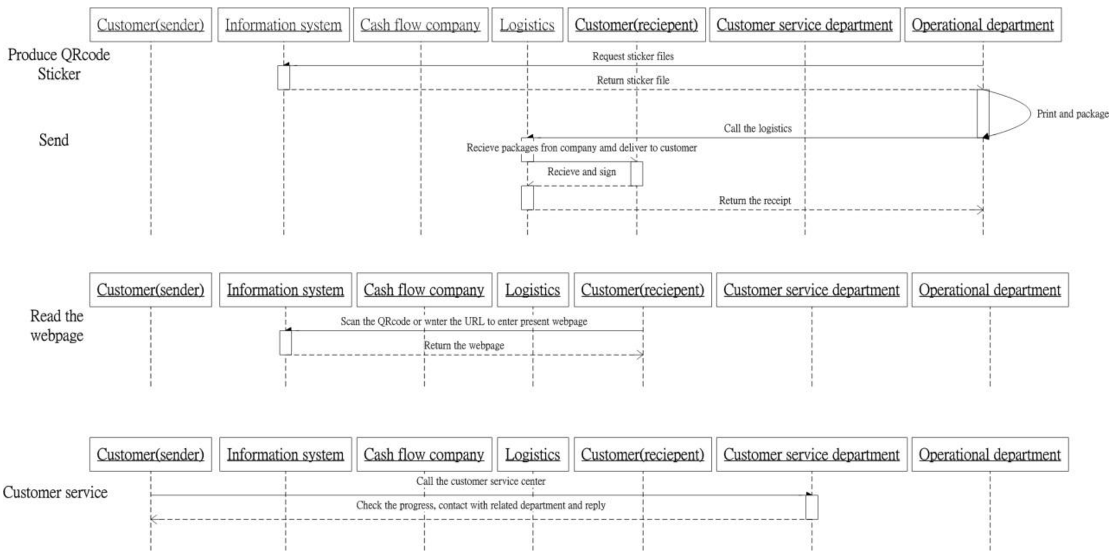


Figure 39: Sequence diagram for product delivery.

5.2.4 Component Diagram for Surprise Service

After designing sequence diagram, we could illustrate the subsystems, components and interfaces by using component diagram (Figure 26). Furthermore, the relations between the components and subsystems, and the tools needs also can be extracted from sequence diagram and illustrated in component diagram. For example, the blue line in figure 27 extracted the tool needed in the operational department by sequence diagram and defined on component diagram. The red line extracted the relations by sequence diagram and illustrated in component diagrams. By component diagram, we can clearly know what tools should be built or purchased in the future and what permissions should be granted to departments and staffs. Component diagram also can help service engineer to design organizational chart in future step.

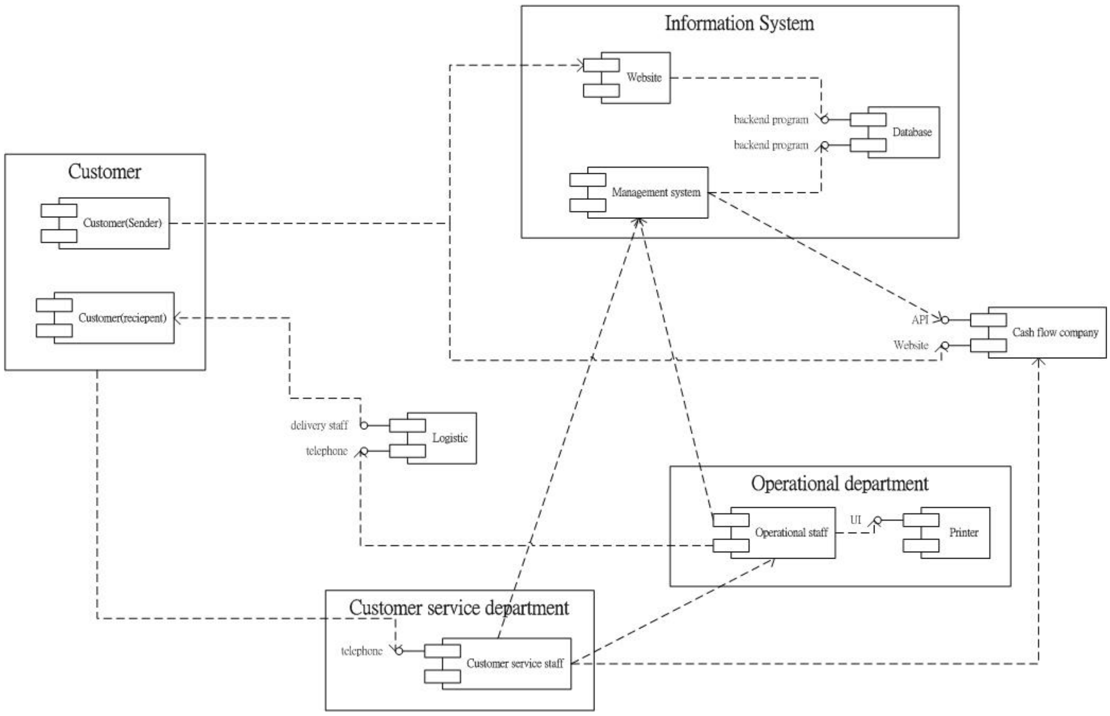


Figure 40: Component diagram for surprise service

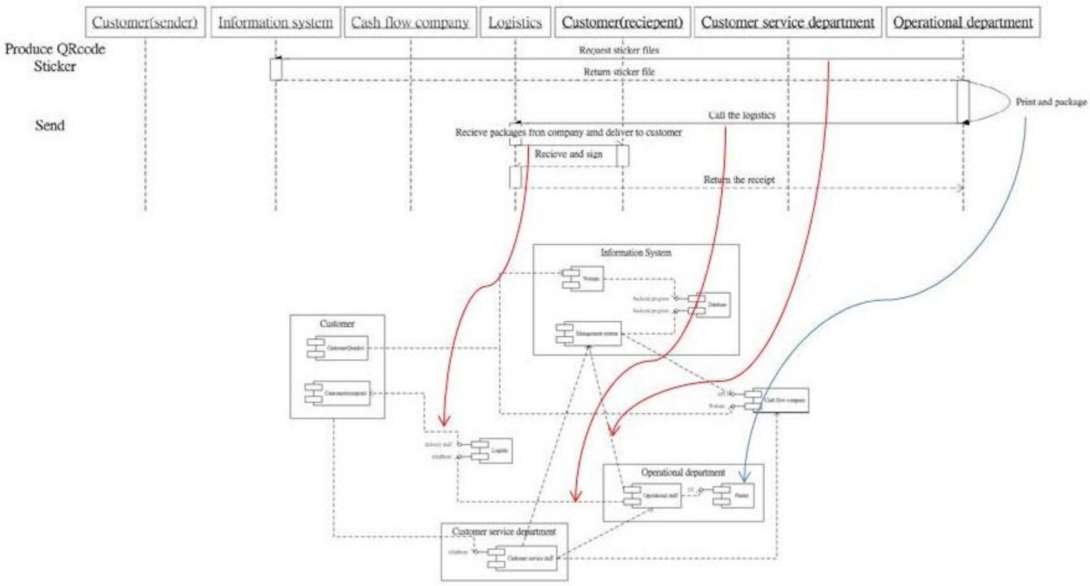


Figure 41: Mapping the ‘send’ sequence to the component diagram.

5.2.5 Organizational Chart and SOP for Surprise Service

From component diagram, we already clearly know what departments and staffs should be included in the organization to provide service. And also clearly know the actions and their orders from sequence diagram. In this step, we will design the organizational chart (Figure 28) and SOP (Figure 29) for managers to refer to plan the department and train the operational staff.

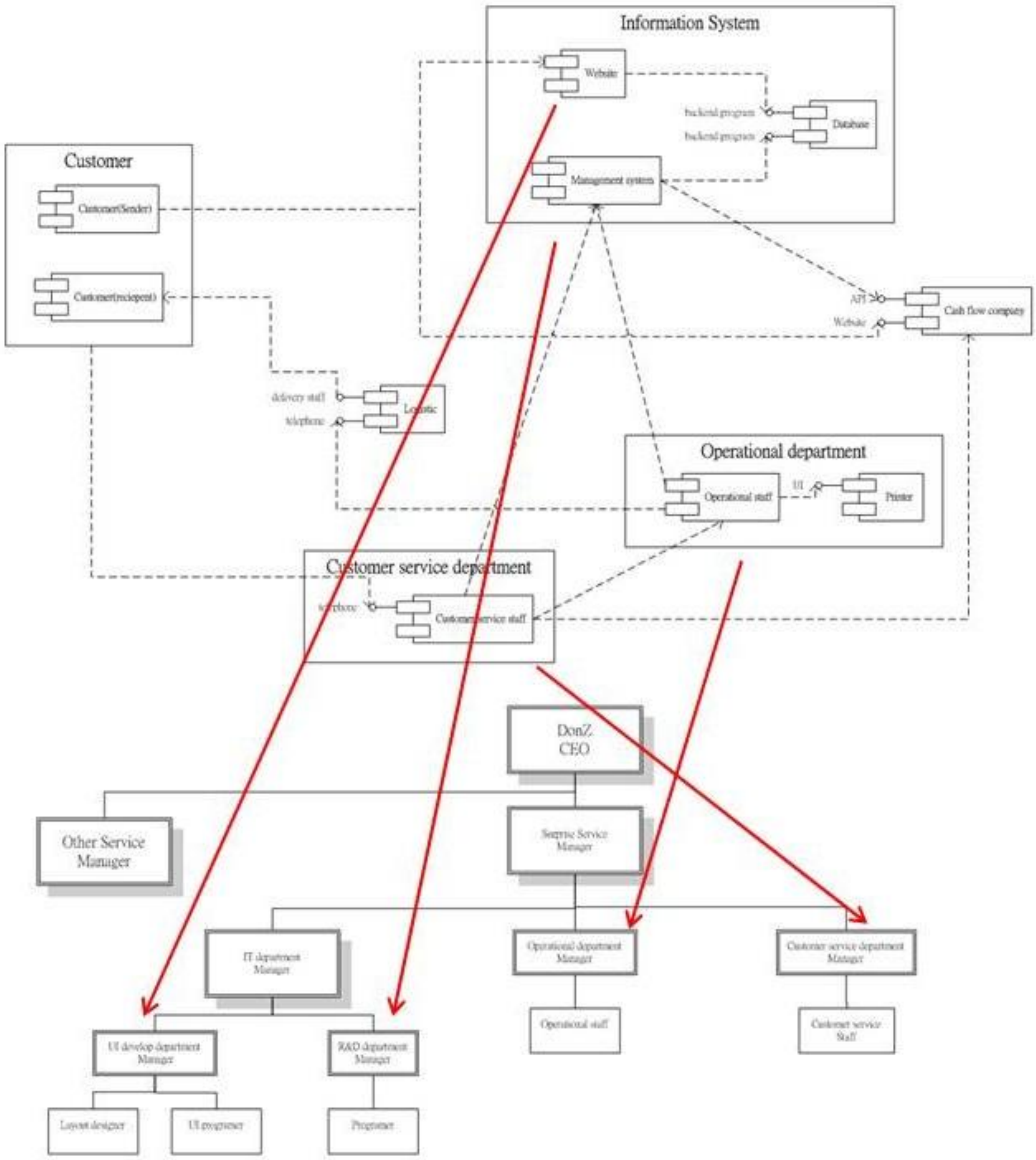


Figure 42: Mapping the components to the organizational chart.

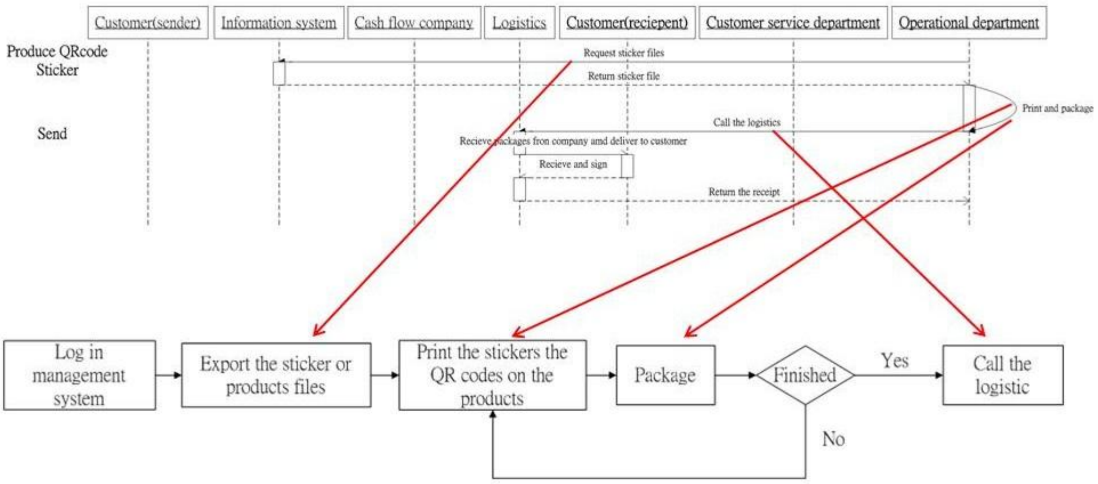


Figure 43: Defining the SOP.

6. OTHER RELATED ISSUES

As mentioned earlier in the paper, while SSME has been researching for more than a decade, some issues on the relation of SSME to other areas of research and the increasing demand of T-professionals are still confusing. For instance, the relations amongst service science and other science, the differences between service management and conventional management, the differences between service system engineering and system engineering are some of these issues needed to be clarified. Nevertheless, should the demand on T-shape professionals be a problem solely existed in service sector is an issue needed to be answered.

6.1 Technology Management

In simple words, technology management focuses on managing the usage of the tools for people to do better job, development of the right tools for people to do better job, and managing the technologies for managing the usage and the development of the tools. In the context of SSME, the roles of technology management have not much difference.

First, technology management is about managing the usage of the technologies to facilitate the operations within a service system. For instance, in the kitchen of a restaurant, one will find ovens, rice cookers, timing machine and refrigerator. The ordering system which connects to the front desk can help the chefs knowing what to cook. All of them are the technologies that can facilitate the chefs to cook. In the context of service engineering, it is managing the usage of the technologies during the “System Maintenance & Review” stage.

Second, technology management is about managing the usage of the technologies for the development of tools to facilitate the operations. For instance, in a restaurant serving BBQ ducks, one will find a special oven which is almost one meter tall and one meter wide. To build such a big oven, people would need to manage the usage of bricks that are heat resistant and the foundation is strong enough to support multiple ducks hanging inside. In the context of service engineering, it is managing the usage of the technologies during the “Implementation” stage.

Third, technology management is about managing the usage of technologies to facilitate the tasks to be accomplished in all steps in service engineering, i.e. the development of new business operations. In the “Analysis and Design” stages, a lot of works have to be done to model, consistency checks and simulate the service system.

For sure, computer system and modeling software are needed. Besides, word processing software is needed for documentation. Special software will also be needed for the system models and designs. In the “Implementation” stage, it is clear that software engineering tools would be needed. If the information system is built on top of cloud platform, managing the usage of cloud will be inevitable. To develop tools, software for new product development would be required. Special tools, like the heat resistant bricks, are needed. Moreover, consider a service engineering project, project management tools are also required for project scheduling and project tracking.

All these technologies are what we need to manage. One point should be noted here. Except information technologies, most technologies to be managed are service specific. One can imagine that the technologies to be used in a restaurant would be very different from the technologies to be used in a health care center. Therefore, the actual context of “Technology Management” should be industrial specific. Sound management of the usage of technologies can only be achieved if sound knowledge in the usage of the technologies has been acquired. Acquisition of the knowledge of those technologies can only be accomplished by experience and on-job learning. Without knowledge on those technologies, it is doubtful if a technology manager could select the right technologies for the business.

6.2 T-Shape Professional

In its early stage (Maglio et al., 2006; Spohrer et al., 2007), researchers in SSME brought out an issue on the demand of T-shape professional. T-shape professionals are those people who are competence in handling different scale of projects and the projects from different disciplines. For sure, T-shape professionals are crucial to the success of a service system. However, training T-shape professionals is only a myth.

T-shape professionals cannot be trained under the environment of a university. The reason is that no university is able to acquire enough industrial projects from different disciplines to let their students to involve. University is unlikely to recruit faculty members who are T-shape professionals. Therefore, from our opinion, training T-shape professionals should not be a focus in SSME. Being a T-shape professional should just be a goal to all SSME professionals. The way to make a SSME professional to be a T-shape professional is by experience, starting from involving in small projects and then large projects, from one discipline to another discipline. After many years, every SSME professional will automatically be a T-shape professional. So, we urge our educators should not put T-shape professional training as one of the objective in their SSME curriculums because it is unlikely achievable.

On the other hand, the demand of T-shape professionals is not the issue limited in the service sector. Every industry demands for T-shape professionals. In a broader sense, T-shape professionals correspond to those people who have knowledge in more than one area. An IT engineer who has acquired knowledge in project management is a T-shape professional. A sale person who has knowledge in network systems is a T-shape professional. A programmer who is able to build information systems for both education sector and health sector is a T-shape professional. In simple words, a person who has both management and technical knowledge is a T-shape professional. A person who has knowledge in more than one technical area is a T-shape professional. It is clear that these kinds of professionals are welcome to any industrial sector. It is not limited to service sector.

6.3 Definitions of Service

In this paper, we have discussed a lot of issues related to 'service'. However, we have not explicitly defined what actually a service is. It is because the definitions of service are quite diverse in different domains. It is also evidenced from the list of special interest groups in the Service Research & Innovation Initiative (SRII).

- Healthcare IT Services
- Financial
- Intelligent Services/Knowledge Management
- Cloud Services
- Telco/Mobile Services
- Service Innovation/Engineering/Quality
- Cross Enterprise Collaboration
- Service Innovation for Public Sectors
- Service Innovation for Emerging Markets
- Environmental Services
- University Research Programs/New Curriculum Development
- IT for Agriculture
- HPC as Services
- Service Management & Marketing

While the focus of SRII is on IT-enable services, the sectors being concerned are clearly quite diversified. A simple definition of service which can cover all these special interest groups is already a research issue.

While it is difficult, there are a few working definitions for service. In service science area, a service corresponds to a provider-client interaction that creates and captures value[8]. It is a change in condition or state of an economic entity (or thing) caused by another. It is intangible, perishable, created and used simultaneously. It is a deed, an act, or a performance. It is any economic activity whose output is not physical product or construction.

In computer Science area, a service is a mechanism to enable access to one or more capabilities, where the access is provided using a prescribed interface and is exercised consistent with constraints and policies as specified by the service description[9]. An operating system provides services to the application systems. An email server provides services to the users of the system. A router serves other routers by forwarding the packets to their destinations. If confined in the area of web services, it is an abstract resource that represents a capability of performing tasks that represents a coherent functionality from the point of view of provider entities and requester entities[10].

In economic, a service is a set of one time consumable and perishable benefits delivered from the accountable service provider, mostly in close co-action with his internal and external service suppliers, effectuated by distinct functions of technical systems and by distinct activities of individuals, respectively, and commissioned according to the needs of his service consumers by the service customer from the accountable service provider. It is rendered individually to an authorized service consumer at his/her dedicated trigger, and, finally, consumed and utilized by the triggering service consumer for executing his/her upcoming business activity or private activity[11].

These definitions are useful for a formal definition of a service system within its domain. To have a general definition which can be applied to all domains, the definition would look very abstract, not easy to be understood by a general public. That is one reason why a formal definition of service has not proposed in this paper.

Another reason for not defining service is because of the evolutionary nature service. As mentioned in (C. Lovelock & Gummesson, 2004), the form of service is evolving over time. The classical definition of service in economic and management is no longer applicable to all kind of services exist in the modern era. For instance, the customers of Internet banking services usually are no need to get involve in the production of the service[12]. From the point of view on the distinction between ser-

[8] http://www.research.ibm.com/ssme/services.shtml
[9] http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=soa-rm
[10] http://www.w3.org/TR/ws-arch/#service
[11] http://en.wikipedia.org/wiki/Service_(economics)
[12] See Table 2 in Loverlock & Gummersson paper.

vices and production, Quinn & Gagnon (1986) have noted[13] that executives and policy analysts often viewed activities like product design, market research, accounting, and data analysis as services if they are provided externally. Internal salespeople are classified under manufacturing employment, but external sales representatives and wholesalers are called service providers. More recently, there is even an advocacy on servitization of manufacturing (Baines, Lightfoot, Benedettini, & Kay, 2009). All these common interpretations elicit the evolutionary nature of services. By no mean, the definition of service if we defined in this paper would probably be changed in the future. Owing not to distract the focus of this paper, we omit a formal definition of service here.

[13] See p.101 in the Quinn & Gagnon paper.

7. CONCLUSIONS

In this paper, we have given a brief review on the current service researches and proposed a process framework for service systems engineering. Then, we have identified that a major problem in the development of service system is on the issue in service systems modeling and thus suggested models which are simple but comprehensive enough to reveal the context of a service system. These models could help managerial professionals, information systems experts and operational staffs to work out a good design for the system.

While various models for a system have been proposed in the area of service marketing, service management and computer science, those models have yet to be connected to provide an integrated picture of a service system. Therefore, we suggested in this paper six simple and yet comprehensive models which facilitate both the managerial and technical professionals to communicate and design an effective service system. The models include (i) use case diagram, (ii) service blueprint, (iii) sequence diagram, (iv) standard operation procedure (SOP), (v) component diagram and (vi) organization chart. These models are keys to succeed an optimal design of a service system. The method how these models can be applied to system design is presented. The applications of these models to modeling a service system are illustrated by a hypermarket example and a business case.

One valuable future work is to conduct a survey on the theories in queuing theory, scheduling, computer simulations and combinatorial optimization and how they are applied to analyze and design an optimal service system. Our work presented in this paper is the first step towards a framework for service engineering. Additional researches should be conducted in the future so as to make it complete, especially on the service system analysis and design. So far, our analysis on a service system is only qualitative. Formal analysis has not been discussed in the paper. It can be accomplished by detail modeling the component diagrams and organization chart. For each of these diagrams, the behavior of each component (department) is modeled mathematically. Then, the mathematical models of the interactions amongst different components (departments) are defined in accordance with the sequence diagrams. Treating each component (department) as a server machine, a service system is yet another system of servers. With knowledge on the arrival rate of the customers and their quality demands, theories in queuing theory, scheduling, computer simulations and combinatorial optimization can thus be applied to do the analysis and reveal the conditions for the design of the service system. Therefore, survey on the theories in queuing theory, scheduling, computer simulations and combinatorial optimization and how they are applied to analyze and design an optimal service system are needed to be done. For some researchers, analysis and design of a service system via analytical approach could already be considered as service engineering[14] (Gans et al., 2003; Mandelbaum, 2007).

Another valuable problem is to survey on the reason why SSME is advocated in the last decade. Some researchers claimed that the reason is due to the rise of service economy. However, it is evidenced from the history of management, management science, systems engineering, technology management, and evolution of the service economy in the last century, the rise of service economy should not be the true reason for establishing the area of SSME. We suspect that two possible reasons. One is due to the increasing complexity of the service systems. The other is due to lacking of professionals who are able to analyze, design and manage such huge systems. Investigation along this direction should be another valuable future research.

[14] It is analogous to electrical engineering which emphasizes a lot on the mathematical techniques and tools on analysis and design of electric circuits.

REFERENCES

Arsanjani, A., Ghosh, S., Allam, A., Abdollah, T., Ganapathy, S., & Holley, K. (2008). SOMA: A method for developing service-oriented solutions. *IBM Systems Journal*, *47*(3), 377–396.

Badinelli, R. (2010). A stochastic model of resource allocation for service systems. *Service Science*, *2*(1-2), 76–91.

Baines, T. S., Lightfoot, H. W., Benedettini, O., & Kay, J. M. (2009). The servitization of manufacturing: A review of literature and reflection on future challenges. *Journal of Manufacturing Technology Management*, *20*(5), 547–567.

Baltacioglu, T., Ada, E., Kaplan, M. D., Yurt, O., & Kaplan, C. Y. (2007). A new framework for service supply chains. *The Service Industries Journal*, *27*(2), 105–124.

Barrutia, J. M., & Gilsanz, A. (2013). Electronic service quality and value: Do consumer knowledge-related resources matter? *Journal of Service Research*, *16*(2), 231–246.

Berg, D., Tien, J. M., & Wallace, W. A. (2001). Introduction to the special cluster on technology management in the service industries. *IEEE Transactions on Engineering Management*, *48*(3), 330–332.

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

Bitner, M. J., Ostrom, A. L., & Morgan, F. N. (2008). Service blueprinting: A practical technique for service innovation. *California Management Review*, *50*(3), 66–94.

Bitner, M. J., Zeithaml, V. A., & Gremler, D. D. (2010). Technology's impact on the gaps model of service quality. In P. P. Maglio, C. A. Kieliszewski, & J. C. Spohrer (Eds.), *Handbook of Service Science* (pp. 197–218). Springer US. Retrieved from http://link.springer.com/chapter/10.1007/978-1-4419-1628-0_10

Bonabeau, E. (2002). Agent-based modeling: Methods and techniques for simulating human systems. *Proceedings of the National Academy of Sciences*, *99*(90003), 7280–7287.

Böttcher, M., & Fähnrich, K.-P. (2010). Modeling of service systems. *International Journal of Service Science, Management, Engineering, and Technology*, *1*(4), 1–11.

Böttcher, M., & Fähnrich, K.-P. (2011). Service systems modeling: Concepts, formalized meta-model and technical concretion. In H. Demirkan, J. C. Spohrer, & V. Krishna (Eds.), *The Science of Service Systems* (pp. 131–149). Springer US. Retrieved from http://link.springer.com/chapter/10.1007/978-1-4419-8270-4_8

Böttcher, M., & Fähnrich, K.-P. (2013). Modeling of service systems. *International Journal of Service Science, Management, Engineering, and Technology*. Retrieved from http://www.irma-international.org/viewtitle/49695/

Brown, L., Gans, N., Mandelbaum, A., Sakov, A., Shen, H., Zeltyn, S., & Zhao, L. (2005). Statistical analysis of a telephone call center: A queueing-science perspective. *Journal of the American Statistical Association*, *100*(469), 36–50.
Buera, F. J., & Kaboski, J. P. (2009). *The Rise of the Service Economy* (Working Paper No. 14822). National Bureau of Economic Research. Retrieved from http://www.nber.org/papers/w14822
Bullinger, H.-J., Fähnrich, K.-P., & Meiren, T. (2003). Service engineering—methodical development of new service products. *International Journal of Production Economics*, *85*(3), 275–287.
Carbone, L. P., & Haeckel, S. H. (1994). Engineering customer experiences. *Marketing Management*, *3*(3), 8–19.
Cardoso, J., Voigt, K., & Winkler, M. (2009). Service engineering for the Internet of services. In J. Filipe & J. Cordeiro (Eds.), *Enterprise Information Systems* (pp. 15–27). Springer Berlin Heidelberg. Retrieved from http://link.springer.com/chapter/10.1007/978-3-642-00670-8_2
Chang, W.-L., Yuan, S.-T., & Hsu, C. W. (2010). Creating the experience economy in e-commerce. *Commun. ACM*, *53*(7), 122–127.
Chen, H.-M. (2008). Towards service engineering: Service orientation and business-IT alignment. In *Proceedings of the 41st Annual Hawaii International Conference on System Sciences* (pp. 114–114).
Chen, H.-M., Perry, O., & Kazman, R. (2009). An integrated framework for service engineering: a case study in the financial services industry. In *Proceedings of ICEC 09* (pp. 269–278). New York, NY, USA: ACM.
Chen, Y., & Tsai, W.-T. (2011). Service-orientation in computing curriculum. In *Proccedings of the 2011 IEEE 6th International Symposium on Service Oriented System Engineering (SOSE)* (pp. 122–133).
Crowder, R. M., Robinson, M. A., Hughes, H. P. N., & Sim, Y.-W. (2012). The development of an agent-based modeling framework for simulating engineering team work. *IEEE Transactions on Systems, Man and Cybernetics, Part A: Systems and Humans*, *42*(6), 1425–1439.
Demirkan, H., & Dolk, D. (2013). Analytical, computational and conceptual modeling in service science and systems. *Information Systems and e-Business Management, 11*(1), 1–11.
Forrester, J. W. (1961). *Industrial Dynamics* (Vol. 2). MIT press Cambridge, MA.
Fuchs, V. R. (1968a). Some implications of the growth of a service economy. In *The Service Economy* (pp. 183–200). NBER.
Fuchs, V. R. (1968b). *The Service Economy* (NBER Books). National Bureau of Economic Research, Inc. Retrieved from

http://ideas.repec.org/b/nbr/nberbk/fuch68-1.html
Fuchs, V. R. (1977). *The Service Industries and U.S. Economic Growth Since World War II* (Working Paper No. 211). National Bureau of Economic Research. Retrieved from http://www.nber.org/papers/w0211
Fuchs, V. R. (1982). *Economic Growth and the Rise of Service Employment* (Working Paper No. 486). National Bureau of Economic Research. Retrieved from http://www.nber.org/papers/w0486
Gans, N., Koole, G., & Mandelbaum, A. (2003). Telephone call centers: Tutorial, review, and research prospects Noah Gans • Ger Koole • Avishai Mandelbaum. *Manufacturing and Service Operations Management*, *5*(2), 79 – 141.
Glushko, R. J. (2008). Designing a service science discipline with discipline. *IBM Systems Journal*, *47*(1), 15 – 27.
Glushko, R. J., & Tabas, L. (2009). Designing service systems by bridging the "front stage" and "back stage." *Information Systems and e-Business Management*, *7*(4), 407 – 427.
Gremler, D. D., Bitner, M. J., & Zeithaml, V. A. (2012). *Services Marketing* (6th ed.). MaGraw-Hill/Irwin.
Grönroos, C. (1984). A service quality model and its marketing implications. *European Journal of Marketing*, *18*(4), 36 – 44.
Hara, T., Arai, T., & Shimomura, Y. (2006). A concept of service engineering: A modeling method and a tool for service design. In *Proceedings of the ICSSSM 2006* (Vol. 1, pp. 13 – 18).
Hostage, G. (1975). Quality control in a service business. *Harvard Business Review*, *53*(4), 98 – 106.
Hsiao, S.-L., & Yang, H.-L. (2010). A service experience engineering (SEE) method for developing new services. *International Journal of Management*. Retrieved from http://www.highbeam.com/doc/1P3-2184287331.html
Jennings, N. R. (1999). Agent-Based computing: Promise and perils. In *Proccedings of the 16th International Joint Conference on Artificial Intelligence (IJCAI-99)* (pp. 1429 – 1436). Retrieved from http://eprints.soton.ac.uk/252172/
Jiang, J. J., Klein, G., Tesch, D., & Chen, H.-G. (2003). Closing the user and provider service quality gap. *Communications of ACM*, *46*(2), 72 – 76.
Kast, F. E., & Rosenzweig, J. E. (1972). General systems theory: Applications for organization and management. *Academy of Management Journal*, *15*(4), 447 – 465.
Kim, H. (2007). The shift to the service economy: Causes and effects. In *Bank of Korea Economic Papers 10 (No. 1)* (pp. 169 – 211).
Levitt, T. (1972). Production-line approach to service. *Harvard business review*, *50*(5), 41 – 52.

Levitt, T. (1976). The industrialization of services. *Harvard business review*, *54*(5), 63 – 74.
Lin, F.-R., & Pai, Y.-H. (2000). Using multi-agent simulation and learning to design new business processes. *IEEE Transactions on Systems, Man and Cybernetics, Part A: Systems and Humans*, *30*(3), 380 – 384.
Lin, K.-J. (2008). The design of an accountability framework for service engineering. In *Proceedings of the 41st Annual Hawaii International Conference on System Sciences* (pp. 108 – 108).
Liu, J., & Tsui, K. C. (2006). Toward nature-inspired computing. *Communications of ACM*, *49*(10), 59 – 64.
Lovelock, C., & Gummesson, E. (2004). Whither services marketing? In search of a new paradigm and fresh perspectives. *Journal of Service Research*, *7*(1), 20 – 41.
Lovelock, C. H. (1983). Classifying services to gain strategic marketing insights. *Journal of Marketing*, *47*(3), 9 – 20.
Luczak, H., & Gudergan, G. (2010). The evolution of service engineering—Toward the implementation of designing integrative solutions. In G. Salvendy & W. Karwowski (Eds.), *Introduction to Service Engineering* (pp. 545 – 575). John Wiley & Sons, Inc. Retrieved from http://onlinelibrary.wiley.com/doi/10.1002/9780470569627.ch26/summary
Maglio, P. P., Srinivasan, S., Kreulen, J. T., & Spohrer, J. (2006). Service systems, service scientists, SSME, and innovation. *Commun. ACM*, *49*(7), 81 – 85.
Mandelbaum, A. (2007). *Service Engineering (Science, Management): A subjective View*. Retrieved from http://ie.technion.ac.il/serveng
Margaria, T., & Steffen, B. (2006). Service engineering: Linking business and IT. *Computer*, *39*(10), 45 – 55.
McFarlane, D. (2011). An engineering perspective on service science. In H. Demirkan, J. C. Spohrer, & V. Krishna (Eds.), *The Science of Service Systems* (pp. 257 – 266). Springer US. Retrieved from http://link.springer.com/chapter/10.1007/978-1-4419-8270-4_15
McKay, A., & Kundu, S. (2011). A blueprint for engineering service definition. In I. Ng, G. Parry, P. Wild, D. McFarlane, & P. Tasker (Eds.), *Complex Engineering Service Systems* (pp. 215 – 232). Springer London. Retrieved from http://link.springer.com/chapter/10.1007/978-0-85729-189-9_12
Noran, O. S. (2000). Business modelling: UML vs. IDEF. *Lecture note, Griffith University, School of Computing and Information Technology*, 16 – 23.
OECD. (2000). *The Service Economy* (OECD Business and Industry Policy Forum Series). Paris.
OECD. (2005). *Growth in Services: Fostering Employment, Productivity and Innova-*

tion (OECD Series). Paris.
OECD. (2007). *Globalisation and Innovation in the Business Services Sector* (OECD Series). Paris.
OMG. (2011). Business Process Model and Notation (BPMN) Version 2.0. OMG.
Parasuraman, A., Zeithaml, V. A., & Berry, L. L. (1985). A conceptual model of service quality and its implications for future research. *Journal of Marketing*, *49*(4), 41 – 50.
Parasuraman, A., Zeithaml, V. A., & Berry, L. L. (1988). SERVQUAL: A multiple-item scale for measuring consumer perceptions of service quality. *Journal of Retailing*, *64*(1), 5 – 6.
Patrício, L., Fisk, R. P., & Cunha, J. F. e. (2008). Designing multi-interface service experiences The service experience blueprint. *Journal of Service Research*, *10*(4), 318 – 334.
Patrício, L., Fisk, R. P., Cunha, J. F. e, & Constantine, L. (2011). Multilevel service design: From customer value constellation to service experience blueprinting. *Journal of Service Research*, *14*(2), 180 – 200.
Piccinelli, G., Zirpins, C., & Lamersdorf, W. (2003). The FRESCO framework: an overview. In *Proceedings of the 2003 Symposium on Applications and the Internet Workshops* (pp. 120 – 124).
Pine II, B. J., & Gilmore, J. H. (1998). Welcome to the experience economy. *Harvard business review*, *76*, 97 – 105.
Pine II, B. J., & Victor, B. (1993). Making mass customization work. *Harvard business review*, *71*(5), 108 – 117.
Pinedo, M. L. (2008). *Scheduling: Theory, Algorithms, and Systems* (3rd Edition.). Springer New York.
Qiu, R. G. (2009). Computational thinking of service systems: Dynamics and adaptiveness modeling. *Service Science*, *1*(1), 42 – 55.
Quinn, J. B., & Gagnon, C. E. (1986). Will services follow manufacturing into decline? *Harvard Business Review*, *64*(6), 95 – 103.
Regan, W. J. (1963). The service revolution. *The Journal of Marketing*, 57 – 62.
Scheithauer, G., Voigt, K., Winkler, M., Bicer, V., & Strunk, A. (2011). Integrated service engineering workbench: Service engineering for digital ecosystems. *International Journal of Electronic Business*, *9*(5), 392 – 413.
Seth, N., Deshmukh, S. G., & Vrat, P. (2005). Service quality models: a review. *International Journal of Quality & Reliability Management*, *22*(9), 913 – 949.
Shostack, G. L. (1982). How to design a service. *European Journal of Marketing*, *16*(1), 49 – 63.
Shostack, G. L. (1984). Designing services that deliver. *Harvard business review*,

62(1), 133 – 139.

Simon, H. A. (1962). The architecture of complexity. *Proceedings of the American philosophical society*, *106*(6), 467 – 482.

Spohrer, J., Maglio, P. P., Bailey, J., & Gruhl, D. (2007). Steps toward a science of service systems. *Computer*, *40*(1), 71 – 77.

Sundbo, J. (2002). The service economy: Standardisation or customisation? *The Service Industries Journal*, *22*(4), 93 – 116.

Tien, J. M., & Berg, D. (2003a). Toward service systems engineering. In *Proceedings of the IEEE International Conference on Systems, Man and Cybernetics, 2003.* (Vol. 5, pp. 4890 – 4895). IEEE.

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

Wu, L.-C., & Wu, L.-H. (2010). Service engineering: an interdisciplinary framework. *Journal of Computer Information Systems*, *51*(2), 14 – 23.

Zhang, L.-J. (2009). Modern services engineering. *IEEE Transactions on Services Computing*, 276 – 276.

Zhang, L.-J. (LJ), & Zhang, L.-J. (LJ). (2008). Introduction to the body of knowledge areas of services computing. *IEEE TRANSACTIONS ON SERVICES COMPUTING, IEEE TRANSACTIONS ON SERVICES COMPUTING*, (2, 2), 0062, 0062 – 74, 74.

Zirpins, C., Baier, T., & Lamersdorf, W. (2003). A blueprint of service engineering. In *First European Workshop on Object Orientation and Web Service (EOOWS)*. Darmstadt, Germany.