Journal of Electrical Engineering 5 (2017) 204-218
doi: 10.17265/2328-2223/2017.04.005

A Novel Design Method for Information Services

Yi-Chih Kao[1], Yung-Chia Chang[1], Sheng-Lung Peng[2] and Ruay-Shiung Chang[3]

1. National Chiao Tung University, Hsinchu 30010, Taiwan

2. National Dong Hwa University, Hualien 97401, Taiwan

3. National Taipei University of Business, Taipei City 10051, Taiwan

Abstract: IT (information technology) services are diverse and complex. Numerous service design methods have been developed for designing and developing products. However, owing to the limited availability of useful tools in IT service design, these methods are ineffective. This study proposes an innovative three-dimensional method for designing IT services. The proposed method considers user requirements, an organization's business requirements, service providers' management requirements as well as the decision-making criteria of management representatives to ensure a smooth implementation of a designed IT service. Using this method, a prototype system to improve campus wireless local area network services was developed and tested at a university in Taiwan. The prototype system reduced the need for repetitive authentication and the time required to solve service problems and address user complaints. In addition, the service design team observed an approximately 70% reduction in project cycle time. The proposed method provided a systematic means to organize the design and implementation of IT services.

Key words: Service design and management model, project management, network architecture and design.

1. Introduction

The primary task of an IT (information technology) department is to provide stable and convenient IT services for maintaining competitiveness. Most of the time and resources of a typical IT department are spent on personnel and improving and upgrading the most problematic services. For convenience, firms commonly hire system integration providers to design IT services. Unfortunately, these providers seldom have a clear understanding of the company culture or its service requirements; therefore, they fail to identify key service problems and may propose suboptimal hardware upgrades as a default means to improve service. However, hardware upgrades seldom reduce the number of complaints received or improve the service quality.

The premise of this study is that the above mentioned IT service issues can be resolved by improving service design. It has been suggested that appropriate service designs can improve customer satisfaction [1]. Sangiorgi [2] stated that service design is an important area of research and that it should encompass three fields in both practice and research, namely, investigation of the nature of services and of service design, investigation of product service systems, and investigation of social innovation and sustainability.

Existing service design methods include the TRIZ (theory of inventive problem solving), QFD (quality function deployment), and the service blueprint method. TRIZ and QFD are typically used in product design and development, and the service blueprint technique uses process analysis to improve service quality. IT services are commonly more complex than other services. Therefore, methods such as TRIZ, QFD, and the service blueprint method may not be able to address all aspects of IT service design. Section 2 describes the limitations of these methods.

Generally, IT departments do not design their own services because of a lack of experience in service design. Therefore, this study proposes a systematic IT service design method that considers the unique attributes of IT services, including planning, operations,

Corresponding author: Yi-Chih Kao, Ph.D., research fields: cyber forensics, network performance, software-defined networking and IT service design.

and maintenance. For service providers, the proposed method supports the implementation of the structure and concept of the designed IT service and can be duplicated and used as a reference in subsequent efforts to satisfy service requirements. The proposed method can also increase project completion rates and reduce the project cycle time.

This study was conducted in partnership with a public university in Taiwan (hereafter referred to as University A) to improve its on-campus WLAN (wireless local area network) services. On-campus IT services are diverse and complex, include Internet, e-mail, cloud computing, research, services delivered over networks, and e-library services, and are provided 24 h a day. The proposed method helped IT managers to design campus IT services that incorporate the unique requirements of the faculty, staff, and students (users) on campus in areas such as business, management, and decision making. The proposed method is expected to help University A improve its WLAN and other campus IT services.

The remainder of this paper is organized as follows. Section 2 reviews the literature related to service design methods, Section 3 presents the proposed method, Section 4 presents the results of adopting this method to improve on-campus WLAN services at University A, and Section 5 presents conclusions and suggestions for future research.

2. Literature Review

Recently, multiple service design studies have been published. For example, Morelli [3] proposed a service design and management model in which multidimensional (organization, technology, and the actor's culture) values are implied in service design activities. Papazoglou and van den Heuvel [4] studied service development methods from the viewpoint of a service producer and a requester. Pigneur and Werthner [5] argued that effective service design should focus on users and that flexible service design must be linked to the organizational strategy, business model, and business process of the designing organization. Pernici [6] argued that the service design should consider flexibility and adaptability over the entire service life cycle. With regard to planning, he suggested that more systematic development could be realized using service design to improve the links between user requirements and service construction. Steen et al. [7] recommended that codesigners first identify the goals of the service design project and then align their codesign activities and associated benefits with those goals.

In addition to theoretical discussions of development, several studies have examined the use of TRIZ, QFD, service blueprint, and other methods in service design. TRIZ is a systematic method for product innovation that has been extensively used in engineering and innovative design for approximately half a century. The principles of TRIZ have been successfully used in a wide variety of methods and applications [8-12]. Even though TRIZ integrates systematic innovations with technical solutions, it has never been used for managerial problems. We believe this is due to difficulties in evaluating service quality and identifying the benefits provided by IT services. Therefore, evaluative resources, such as service quality evaluation criteria, components of service quality, the service quality contradiction matrix, and the relationship between the service and the inventive principle, have not been developed for TRIZ-IT. That is, IT service producers, unlike producers in other industries, cannot use TRIZ resources with direct value to their requirements because those resources do not exist.

The QFD method, which is used in the design phase, involves a series of activities (e.g., product design and development, manufacture planning, and production) to deliver products or services that satisfy user requirements. The QFD method has been used successfully in a wide variety of situations [13-20]. QFD is applicable to IT in that it considers time, cost, quality, and risk to improve research, development, processes, and manufacturing. However, QFD is limited by subjectivity when applied to decision-making.

The service blueprint method is based on flowcharts of service implementation processes, user reception locations, user and staff roles, the line of visibility, and support processes. This method helps businesses understand the processes involved in delivering services. The service blueprint method has also been successfully used in several different situations [21-25]. However, in IT service design, the main limitation of the service blueprint method is that it uses flowcharts to analyze service processes, and it lacks a structure that can be used to consider underlying rationales for the steps included in the flowcharts and the factors that influence those steps. Therefore, it cannot be used to analyze the overall service.

The systematic integration of critical aspects of IT service design to ensure that design and implementation processes proceed smoothly has not been fully studied.

3. 3D (Three-Dimensional) IT Service Design

In this study, the above methods are integrated to develop a 3D IT service design method that converts processes into six steps to provide IT service producers with a systematic service design method. The proposed design method considers IT service user requirements, service provider management requirements, business requirements, and a decision-making method for candidate solutions.

The goal of IT service design is to satisfy user requirements and address-related managerial problems. Fig. 1 presents the fundamental concept of the proposed 3D IT service design method. The three dimensions are business, management, and decisionmaking. An IT service design team can categorize managerial problems associated with an IT service using one or more of these dimensions to improve their comprehension of those problems, develop solutions, and propose new service designs.

The following subsections discuss aspects of the business, management, and decision-making dimensions.

3.1 The Business Dimension Components

The first component of the business dimension is organization (B1), which refers to the group of management representatives that provide services and systems, including regulations and implementation details for delivering those services. An organization needs to provide the required resources and confirm the quality of the service delivery process. Therefore, the organizational culture and service strategy, as well as the potential business value, of the services needs to be analyzed before they can be designed.

The second business component is process (B2), which refers to a series of activities in which relevant departments and personnel coordinate for a common purpose through particular service stages or projects. A process is a standard operating procedure that requires compliance by both users and service personnel. The successful delivery of a service depends on a well-defined process.

The third business component is technology (B3), which refers to the professional skills used at different service stages or projects. Efficient service delivery depends on effective techniques to handle information and adequate data analysis. A service design process depends on technical experts who can apply, test, and validate the techniques used to develop or improve services. Service providers also need to master and proactively monitor the technologies used in service design.

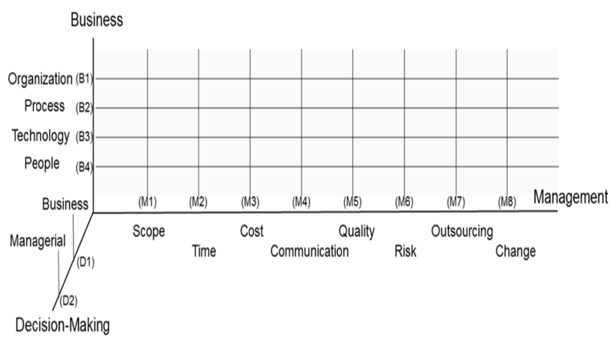

Fig. 1 Conceptual model of the proposed 3D IT service design.

The fourth business component is personnel (B4). Personnel are stakeholders who participate in service or project development. They are assigned specific roles and responsibilities at various stages. They include users, the service design team, service providers, experts, project managers (team), and outsourced vendors. Before a service can be designed, relationships between individual stakeholders and between stakeholders and the service must be acknowledged. The expertise of each stakeholder should be exploited optimally, and user participation should be encouraged to ensure a complete understanding of ideas and requirements.

3.2 The Management Dimension Components

The first component of the management dimension is scope (M1), which includes both the scope of services that an organization can reasonably offer and the scope of services that the organization must provide to reach its highest-level goals. Clearly defining the scope of services is essential for two reasons. First, scope dictates the other components of the management dimension. Second, users always try to pull a service design or improvement out of scope in ways that are unique to individuals rather than common to the goals of the organization and the project. This negatively affects project delivery and quality. Therefore, potential changes need to be weighed against the broader goals of the organization and the desired scope before they are adopted.

Time (M2) is the second component of the management dimension. Here, time refers to the start and end points, order, and scope of the work. The duration and quality of the provided services are directly related to the service cost. Service design should use a linear or nonlinear programming model to optimize resources under constraints.

The third management component is cost (M3), which refers to all expenses associated with providing services, including the cost of quality control. The design and delivery of services are considered to be a cost regardless of where they originate. Service design must consider implementation costs, maintenance, and operating expenditures after delivery. To prevent under-budgeting, the total cost should be calculated as proposed by Ellram and Siferd [26] during service design to estimate all associated costs.

The fourth management component, communication (M4), refers to the processes used by all service stakeholders to communicate and exchange views to reach a mutual understanding. Communication is the most time-consuming and critical part of each stage. Service design must provide an open communication platform for the service team and users. Communication channels may include phone, mail and/or e-mail, a service counter, or a customer service system that provides technical support.

The fifth component is quality (M5). Quality reflects the implementation standards and service processes required to satisfy internal and external user requirements. Service quality directly affects user satisfaction and must be considered throughout the process (before, during, and after service delivery). For example, experts can participate in service design immediately before delivery, service quality can be monitored using automatic malfunction alerts during delivery, service providers can draw on experience to suggest modifications, and service quality can be monitored after delivery through regular audits and surveys.

Risk (M6), the sixth management component, refers to the probabilities and consequences of dangerous situations. No service is risk-free. During service design, the stability and quality of the service and the risk to the resources that an organization has invested need to be evaluated to develop countermeasures and control methods for all stages. Teams need to identify the most likely cause of the next service disaster and maximize improvements to minimize risks. To minimize service risks and the impact of a service disaster on operations, risk analyses should be performed and countermeasures described in business impact assessments [27], business contingency plans [28], and disaster recovery plans [29] should be applied.

The seventh management component is outsourcing (M7), which refers to specific functions, services, tasks, or management responsibilities performed by third parties. To reduce costs and minimize risk, organizations typically outsource business components that are not among the organization's core functions. The roles and responsibilities of both parties must be clearly established in a contract. During service delivery, participants may access personal and confidential data. Therefore, independent of whether the work is outsourced or performed in-house, the organization must protect and manage personal and confidential data. Access to user data or usage rights must be determined in advance and strictly managed by participating organizations during service design, and the nature of the collaboration with external vendors must be consistent with organizational strategies, e.g., through nondisclosure agreements.

Change (M8), the eighth management component, refers to modifications in the scope of service delivery. Changes are inevitable when satisfying rapidly changing user demands. The design process typically considers future service expansions but usually without an associated detailed action plan.

3.3 The Decision-Making Dimension Components

Decisionmaking commonly involves prioritizing or determining the best potential alternatives according to an analysis based on empirical decisionmaking or quantitative assessment tools. Lessons Learned is an empirical decision-making method [30].

Business decision-making (D1) [31] is a process by which an organization sets its future development goals and strategies or the means of achieving these goals.

Managerial decision-making (D2) is an attempts to realize a high degree of coordination among production technologies and economic activities, as well as rational allocation and utilization of resources by various parts of the organization to improve management efficiency.

Quantitative analysis techniques, such as multi-attribute decision-making [32] methods, can be used when the number of service improvement alternatives is limited and known. Table 1 presents the overall score of a candidate solution as a weighted sum of its attribute values obtained using the SAW (simple additive weight) of the multi-attribute utility theory [32]. The score of each candidate solution i (Ai) is obtained by summing the normalized products of the metrics r_{ij} and their assigned weight w_j (for evaluation item j).

The selected solution A*is defined as follows.

$$A^* = \{A_i \mid \max \frac{\sum_{j=1}^{n} w_j r_{ij}}{\sum_{j=1}^{n} w_j}\},\ 1 \le i \le m \tag{1}$$

where m is the number of candidate solutions and n represents the number of evaluation items. In general, $\sum_{j=1}^{n} w_j = 1$.

3.4 Steps Involved in the 3D IT Service Design Method

Six steps to apply the proposed 3D IT service design method are suggested. Fig. 2 shows the relationship between each step and the corresponding stakeholders.

Table 1 SAW (simple additive weight) method.

I	S_1	S_2	…	S_m
w_1	r_{11}	r_{12}	…	r_{1m}
w_2	r_{21}	r_{22}	…	r_{2m}
…	…	…	…	…
w_n	r_{n1}	r_{n2}	…	r_{nm}
A	A_1	A_2	…	A_m

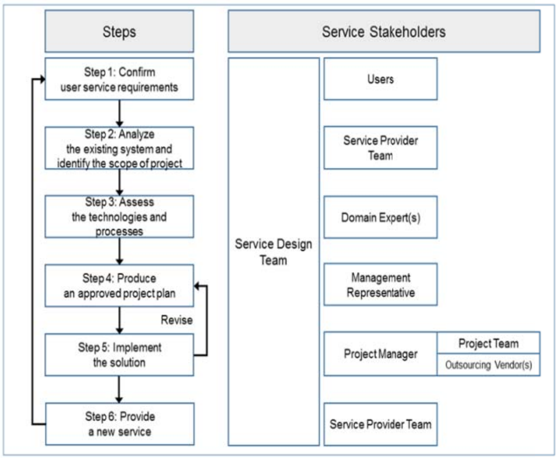

Fig. 2 Relationships between the six steps of the 3D IT service design method and the stakeholders.

The six steps are described as follows.

Step 1. Confirm user requirements

The design team may identify user requirements or analyze key service problems using interviews, questionnaires, and service performance reports. This step includes reviewing the records of previous projects in the analysis of service problems.

Step 2. Analyze existing system and identify project scope

The service design team should examine the design and data used in the existing system to identify limitations and gaps between existing services and user expectations. For service gaps, the design team should first select components of the business dimension to facilitate business decisions and then select components of the management dimension to facilitate managerial decisions. The service design team can work with the service provider team to identify the scope of the improvement project by mapping the work items in the 3D IT service design model.

Step 3. Assess technologies and processes

The service design team should solicit advice from experts to eliminate the gaps identified in Step 2. The design team should evaluate the applicability of technologies, possible improvements to service processes, service costs, system integration, and risks associated with any change. The design team can then suggest solutions, which should be validated via discussions with domain experts.

Step 4. Produce an approved project plan

Based on the results of the assessment performed in Step 3, in Step 4, the items used to evaluate the solutions must be carefully considered. All solutions must be evaluated using the same evaluation items and weights. Consensus regarding the evaluation items and weights is achieved using the Delphi method. Management representatives should consider organizational resources, the urgency of the service, the capabilities and capacity of the service team, expert advice, and other factors. After the evaluation items and weights have been determined, management representatives (decisionmakers) score all evaluation items for each solution. The SAW method is used to analyze candidate solutions, which can then be ranked. The top solution is used in the next step, in which the design team produces a project plan based on the selected solution that is approved by the management representatives.

Based on the service improvement project goals, the design team selects executive highlights for the project scope. Each pair of selected components specifies an intersection point, which indicates a corresponding work item for consideration during solution planning.

The design team performs detailed planning based on the above work items. The management representatives may repeat the decision-making process several times before finalizing a detailed plan.

Tables 2-5 present the highlights of the planning phase. On the basis of the goals of the service improvement project, the design team selects executive highlights as the project scope. Each pair of selected components specifies an intersection point, which indicates a corresponding work item for consideration during solution planning.

The design team performs detailed planning on the basis of the abovementioned work items. The management representatives may have to repeat the decision-making process several times before finalizing a detailed plan.

Table 2 Executive highlights concerning the organization in the planning phase.

No.	Intersection point (work item)	Responsible person	Executive highlights
1	Organization /Scope	Management representative	Confirm the scope of the service improving project and establish mechanisms for assessing progress.
2	Organization /Time	Management representative	Specify the time of each work items.
3	Organization /Cost	Management representative	Determine the service budget.
4	Organization /Communication	Management representative	Avoid vague and uncertain terms when communicating.
5	Organization /Quality	Management representative	Determine the standards of quality for the service.
6	Organization /Risk	Management representative	Identify the assumptions and risks.
7	Organization /Outsourcing	Management representative	Identify the company culture, business strategy, and outsourcing flexibility and limitations.
8	Organization /Change	Management representative	Determine the procedures for change and their flexibility and limitations.

Table 3 Executive highlights concerning the process in the planning phase.

No.	Intersection point (work item)	Responsible person	Executive highlights
1	Process /Scope	Design team	Assess whether any changes to the service process influence the scope and objectives of the service.
2	Process /Time	Design team	Assess whether any changes to the service process reduce the waiting time.
3	Process /Cost	Design team	Assess whether any changes to the service process can reduce service costs.
4	Process /Communication	Design team	Assess whether any new service process is transparent and well-known by the stakeholders
5	Process /Quality	Design team	Assess whether any changes to the service process can improve the quality of service.
6	Process /Risk	Design team	Assess whether any changes to the service process can reduce risks of service delivery
7	Process /Outsourcing	Design team	Assess whether any changes to the service process can improve outsourcing management.
8	Process /Change	Design team	Assess whether any changes to the service process can improve service management.

Table 4 Executive highlights concerning the technology in the planning phase.

No.	Intersection point (work item)	Responsible person	Executive highlights
1	Technology /Scope	Design team	Analyze the existing system. Assess whether any new technique is within the scope of the service-improving project.
2	Technology /Time	Design team	Assess whether any changes to the service technique reduces the waiting time.
3	Technology /Cost	Design team	Assess whether the new techniques reduce the service costs.
4	Technology /Communication	Design team	Assess whether the new techniques are acceptable to the stakeholders.
5	Technology /Quality	Design team	Assess whether the new techniques improve the quality and stability of service.
6	Technology /Risk	Design team	Assess possible risks associated with the new techniques.
7	Technology /Outsourcing	Design team	Assess the need for new technical outsourcing.
8	Technology /Change	Design team	Assess the need for new technical changes.

Table 5 Executive highlights concerning the personnel in the planning phase.

No.	Intersection point (work item)	Responsible person	Executive highlights
1	Personnel /Scope	Design team	Individual items or outsourced items. Determine the scope of the management plan.
2	Personnel /Time	Design team	Select the work order and workload. Estimate the project completion time. Develop the time management plan.
3	Personnel /Cost	Design team	Assess the resource requirements and estimate the project costs. Develop the cost management plan.
4	Personnel /Communication	Design team	Confirm stakeholder roles and responsibilities. Develop the communication management plan.
5	Personnel /Quality	Design team	Assess the professional competence of the service delivery team. Develop the quality management plan.
6	Personnel /Risk	Design team	Assess the stakeholder risks associated with executing the plan. Develop the risk management plan.
7	Personnel /Outsourcing	Design team	Develop the formal solicitation and selection processes. Develop the outsourcing management plan.
8	Personnel /Change	Design team	Assess the need for change. Develop the change management plan.

The project enters the implementation phase immediately after the management representatives hold a kickoff meeting.

Step 5. Implement the solution

This step includes implementing and confirming the effectiveness of the proposed problem solution procedure and determining whether further improvement is required. The selected solution becomes a formal service only after it is executed and corrected carefully.

Tables 6-8 show the implementation phase, monitoring and controlling phase, and closing phase as well as the recommended work items.

The project manager assigned by the organizational service management representative needs to lead the project team in implementing the improvement project. The management representative should audit and guide the implementation of the project to ensure quality. During the implementation process, consent of the management representative is generally required when the scope, cost, or quality of the project change. The project manager is typically responsible for maintaining good communication among stakeholders by providing effective project team management, conducting regular project review meetings, and resolving conflict efficiently throughout the project life cycle.

If the expected benefits cannot be realized after the best improvement solution is executed, the organization must return to Step 4 to reselect the next best solution using quantitative evaluation methods.

Step 6. Provide a new service

When providing a new service, the methods for monitoring the service and automatically detecting service exceptions are as important as the new solution itself. After the methods to monitor the recognized problems have been implemented, problems should be solved promptly rather than being logged for future consideration.

In this step, the service provider officially provides a new service. The service communication platform should be sufficiently transparent to enable the identification of user requirements and service problems, and a service management system should be established to improve the service actively and continuously.

The proposed 3D IT service design method has six steps. The project manager and his team implement the design method by completing the work items according to the plan. In the implementation process, the project manager monitors the project indices to verify satisfactory performance. Two steps to ensure continuous improvement are suggested. First, identify the root cause of a failure and define the direction for improvement. Second, if the root cause cannot be clearly identified, the management representative should

Table 6 Executive highlights concerning the implementation phase.

No.	Intersection point (work item)	Responsible person	Executive highlights
1	Organization /Communication	Management representative	Perform regular project review meetings. Reduce the risks associated with the project.
2	Organization /Quality	Management representative & project manager	Audit project quality when implementing the project.
3	Organization /Change	Management representative	Guide and manage the implementation of the project. The management representative must approve the scope, cost, and quality changes.
4	Personnel /Communication	Project manager	Ensure smooth communication between the service stakeholders; efficient management by the project management team; efficient conflict resolution and regular project review meetings.
5	Personnel /Outsourcing	Project manager	Select outsourcing vendors.

Table 7 Executive highlights concerning the monitoring and controlling phase.

No.	Intersection point (work item)	Responsible person	Executive highlights
1	Organization /Scope	Management representative	Assess whether each milestone is met.
2	Personnel /Scope	Project manager	Monitor the scope of the project to avoid diverging from user requirements. Ensure that the service requirements are met at each stage.
3	Personnel /Time	Project manager	Monitor progress.
4	Personnel /Cost	Project manager	Monitor costs.
5	Personnel /Communication	Project manager	Monitor communication mechanisms. Immediately notify the project stakeholders of any changes to the project.
6	Personnel /Quality	Project manager	Monitor quality.
7	Personnel /Risk	Project manager	Monitor risks.
8	Personnel /Outsourcing	Project manager	Manage vendors to whom work has been outsourced and the quality of their work.
9	Personnel /Change	Project manager	Implement procedures for change and prepare the execution efficiency report.

Table 8 Executive highlights concerning the closing phase.

No.	Intersection point (work item)	Responsible person	Executive highlights
1	Technology /Change	Project manager & project team	Update and record configuration changes.
2	Personnel /Quality	Project manager & project team	Receive user feedback and suggestions and continue improving the service.
3	Personnel /Change	Project manager & project team	Update the "lessons learned" knowledge base.

be consulted to determine an acceptable solution. In the service improvement project cycle, the lessons learned by the project managers and their teams can be systematically collected in a knowledge database to provide a reference when satisfying new service requirements and implementing new improvements.

4. Case Study: Improving the WLAN Services of University A

University A, a public university in Taiwan, has nine colleges with 700 full-time faculty members and 14,000 students. Currently, WLAN services are provided by 1,000 wireless access points in a thin client service architecture distributed throughout the campus. The minimum security requirement of the WLAN services is the authentication of user identity. In conventional identity authentication methods, users enter an account name and password whenever they connect, which is inconvenient. The information center spends at least 100 person-hours per month troubleshooting WLAN service problems or responding to user complaints. A major challenge is to resolve the tension between service convenience and management requirements with limited human resources. The feasibility and effectiveness of the proposed 3D IT service design method were verified by using it to improve the convenience of the WLAN services at University A's information center.

Step 1. Confirm user service requirements

An analysis of user complaints and suggestions by the service design team revealed that most users preferred to access WLAN services without repeatedly entering usernames and passwords for ID verification.

Step 2. Analyze the existing system and identify the project scope

To obtain a clear understanding of WLAN usage, the Aruba Networks AirWave [33] WLAN management system at University A was observed for 30 days. An analysis of the service records revealed that approximately 29% of WLAN service requests involved incorrect input of account names or passwords. The service design team also analyzed the WLAN service architecture, mode of operation, and management in the existing system. Fig. 3 shows the pre-improvement ID verification process. To access WLAN services, users were required to select a service set identification and enter their username and password into the WLAN login portal. Once their identity was verified by a RADIUS server, the user was added to the user authorization list and allowed access. Approximately 5,000 users at University A accessed WLAN services four times per day on an average, and the authentication process took approximately 30 s for each login.

Step 2 includes identifying the scope of the service design project by mapping work items in the 3D IT service design model. As shown in Fig. 4, the items of concern in this service improvement project were as follows: confirm the scope of the improvement project and establish mechanisms for assessing progress (Organization/Scope); reduce the service budget (Organization/Cost); assess whether any new service process is transparent (Process/Communications); assess whether the new technologies improve service quality and stability (Technology/Quality); evaluate the professional competence of the service delivery team; and develop a quality management plan (Personnel/Quality).

Step 3. Assess technologies and processes

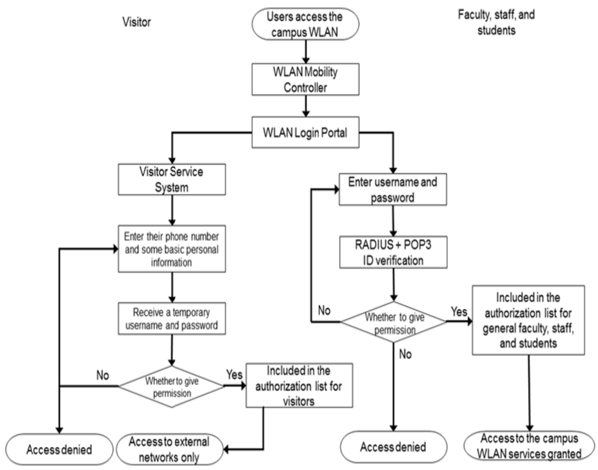

Fig. 3 Campus WLAN (wireless local area network) service ID verification at University A (pre-improvement).

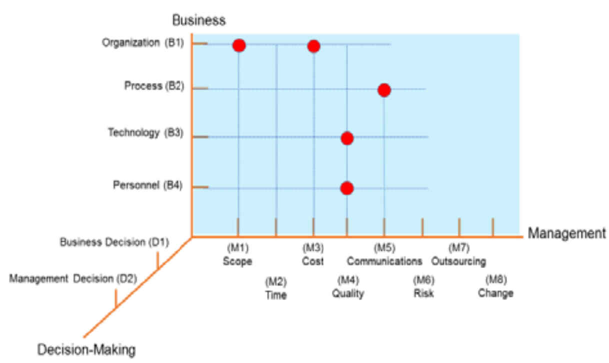

Fig. 4 The items of concern in the service improvement project.

For University A, an assessment by two WLAN service experts revealed that simplifying the user ID verification process could improve verification without compromising network security. ID verification could be based on devices rather than on users, and an authentication mechanism could be inserted between the WLAN controller and the login portal during automatic identification. There are two possible solutions in this case: the in-house engineers make the desired change via coding or vendor engineers implement purchased commercial software that satisfies user expectations.

Step 4. Produce an approved project plan

The two possible solutions were evaluated. Domain experts weighted five evaluation items using the Delphi method. Fig. 5 shows the mapping of the evaluation items in the decision-making dimension.

The evaluation items were as follows: (1) the system meets requirements (derived from the intersection point of Organization/Scope, weight 0.3); (2) the total cost of ownership is reasonable (derived from the intersection point of Organization/Cost, weight 0.25); (3) the system is stable and expandable (derived from the intersection point of Technology/Quality, weight 0.25); (4) the user interface is acceptable (derived from the intersection point of Process/Communications, weight 0.1); and (5) engineers are familiar with the technology (derived from the intersection point of Personnel/Quality, weight 0.1). Table 9 presents the evaluation items and weights used for solution selection.

After the five evaluation items and their weights were determined, management representatives rated the items for each solution for improving convenience in authenticating user identity. After scoring was completed, the SAW method was used to perform the analysis. Coding by in-house engineers achieved the highest total score and was selected as the preferred solution.

The final service design project plan included an MAC (media address control) address that is unique to each network device. Using MAC addresses as the user identity authentication mechanism was the most economical and convenient method. However, considering the risk of MAC address spoofing, we enabled the function “automatic client blacklisting due to spoofed de-authentication detection” on the Aruba Wireless Controller to detect whether MAC addresses of networking devices overlap. This mechanism is used to judge whether MAC address spoofing occurs and to automatically block the overlapped MAC addresses in real time. Meanwhile, different degrees of permission were given to users accessing non-restricted data to reduce the risk resulting from MAC address spoofing.

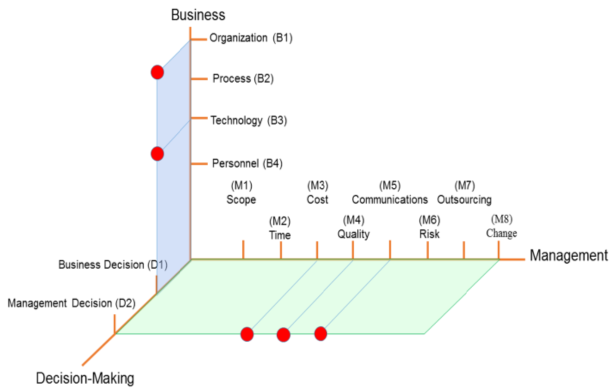

Fig. 5 Five evaluation items mapped to the decision-making dimension.

Table 9 Evaluation items and weights used in solution selection.

Evaluation items/Weight \ Solutions		Coding by in-house engineers	Purchase commercial software package
1. System meets the requirements	0.3	100	100
2. Total cost of ownership is reasonable	0.25	100	50
3. System is stable and expandable	0.25	75	75
4. User interface is acceptable	0.10	75	100
5. Engineers are familiar with the technology	0.10	75	100
Total score		88.75	81.25

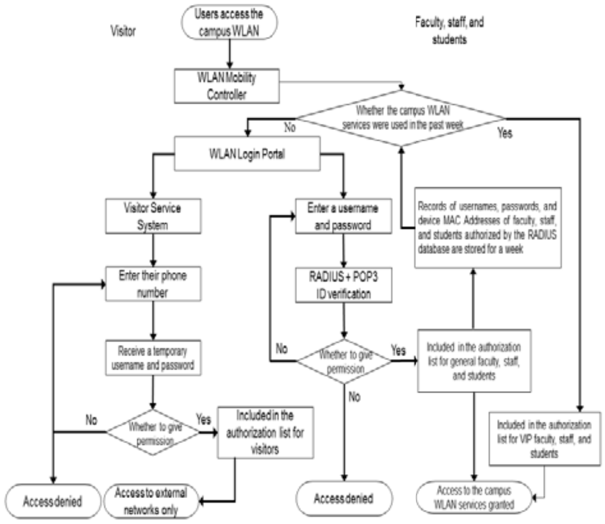

Fig. 6 The improved user authentication process for campus WLAN services.

Fig. 6 shows that the improved user authentication process inserts a determination and storing mechanism between the original WLAN mobility controller and the login portal. A MySQL program is run on the RADIUS server to automatically write the username and MAC address of a user's mobile device in the RADIUS server database when a user is authenticated for the first time. Therefore, whenever a user subsequently accesses WLAN services, the mobility controller checks whether a record exists for that MAC address. If a record exists, the system adds the corresponding username to the authorization list and grants immediate access. If the record does not exist, the system requests ID verification via the WLAN login portal. Statistical data concerning the Aruba AirWave WLAN management system at University A indicate that 80% of the users access WLAN services at least once every seven days. Therefore, the database used in the proposed system stores MAC addresses that have been authenticated within the previous seven days. Within this seven-day period, a user can access the network using an authenticated mobile device without entering a username and password, and a record of each successful authentication is automatically stored in the database for a further seven days. Therefore, users who frequently access the network using an authenticated device rarely have to re-enter authentication information.

To simplify the process of entering information for visitors accessing campus WLAN services, visitors are only required to enter their phone number and a random four-digit verification code. They then receive a text message that contains a temporary username and password. However, for security reasons, University A only permits visitors to access HTTP and HTTPS services.

Step 5. Implement the solution

The developed service system was tested for ID verification using device MAC addresses. In the MySQL program written by the in-house engineers (Q4 2013), the username and MAC address of each mobile device were automatically written to the RADIUS server database whenever a username and password were first authenticated. The new WLAN service model was implemented without an official announcement because no changes to user behavior or hardware settings were required. Users were automatically authenticated using only an MAC address. During the three-month test period, users were unaware of the change.

When an information security incident occurred, the service provider could identify the user rapidly (within 1 min) by searching the network address translation server log for the time of the incident and the IP address.

Step 6. Provide a new service

A complete WLAN service monitoring mechanism was established as part of University A's network management system. When a problem is detected, the system notifies the provider in real time by sending a short message. To collect statistical data related to the repairs required to maintain the service quality standards established by the service management representatives, University A developed a service tracking system that complies with ISO 20000 [34]. If a sufficient number of users report dissatisfaction with the service model or content, the service design team can repeat Step 1 to review user requirements and service issues.

Before the described improvement was implemented, the users at University A required approximately 30 s to authenticate their account before accessing WLAN services. After the service provider applied the six steps of the proposed 3D IT service design method to improve WLAN services, users did not need to repeatedly enter usernames and passwords. Visitors could also access WLAN by simply entering a verification code rather than providing personal data. Since its implementation at University A in January 2014, the system operated effectively for 18 months. According to the statistical data collected over this period, the average time taken by the information center to solve WLAN service problems or handle user complaints decreased from 100 h per month to 25 h per month, reducing the time required to solve problems by approximately 75%. Moreover, the new service model does not require additional hardware and reduces the service time.

The design method enabled the improvement team members to quickly and easily identify the scope of the project and the work direction by selecting the work items that were recommended to improve service. The design team determined that the proposed 3D IT service design method was superior to methods that had been used in previous improvement projects. The management representatives of the information center also noted that due to a lack of experience, several previous implementation projects required 7-10 problem-resolution iterations. Combining the systematic guidelines developed in this study with the recommendations of the service design team and domain experts reduced the number of problem resolution iterations to approximately three and reduced the risk of design flaws. The proposed method reduced the time required to plan service projects by approximately 70%.

5. Conclusions and Future Research

University IT service staff typically have limited ability to design services. Therefore, campus IT service improvements are usually made only when equipment suppliers recommend hardware upgrades. This study provided the IT staff at University A with a simple and systematic design method to improve IT service quality using existing hardware. Even though several IT service design studies have reported the successful application of the TRIZ, QFD, and service blueprint methods, university IT staff typically find implementing these IT service design methods extremely difficult.

In this study, a structural guide was used to develop a simple and systematic design method to design campus IT services. This method was developed by integrating the best practices of project management, information service management, and decisionmaking, requires a complete analysis before service changes are made, and considers service management and business integration. With this method, IT staff can lower the failure risk of IT project design and deliverables and create a win-win configuration for all IT service stakeholders.

In the case study, the proposed 3D IT service design method was employed to demonstrate the feasibility and effectiveness of the proposed method. In any service field in which the proposed approach is applied, the service design team must first understand user requirements and master the processes and techniques required in service delivery to design a service system that benefits both the implementing organization and its users.

An IT service that satisfies the user and management requirements is likely to succeed. Providing users with stable and high quality IT services at a low cost is a common goal of IT service design teams. However, the rapid development of IT is expected to increase service complexity and cross-industry service integration. This study confirmed the effectiveness and feasibility of the proposed design method in improving and designing IT services at University A. In the future, the authors will address the application of the proposed method to cross-industry integration services.

Note: This paper is extended version of the "A Novel Method for Designing Information Technology Services" submitted in The IEEE 2016 International Conference on Computer and Information Technology [35].

References

[1] Isa, M. F. M., and Usmen, M. 2014. "Improving University Facilities Services Using Lean Six Sigma: A Case Study." *J Facil. Manag.* 13: 70-84.

[2] Sangiorgi, D. 2016. "Building up a Framework for Service Design Research." In 8th European Academy of Design Conference, Aberdeen, Scotland, 415-20.

[3] Morelli, N. 2002. "Designing Product/Service Systems: A Methodological Exploration." *Design Issues* 18: 3-17.

[4] Papazoglou, M. P., and van den Heuvel, W. J. 2006. "Service-Oriented Design and Development Methodology." *IJWET* 2: 412-42.

[5] Pigneur, Y., and Werthner, H. 2009. "Design and Management of Business Models and Processes in Services Science." *ISeB* 7 (2): 119-21.

[6] Pernici, B. 2010. "Methodologies for Design of Service-Based Systems." In *Intentional Perspectives on Information Systems Engineering*, Springer, Berlin, Heidelberg, 307-18.

[7] Steen, M., Manschot, M., and de Koning, N. 2011. "Benefits of Co-design in Service Design Projects." *Int. J Design* 5 (2): 53-60.

[8] Low, M. K., Lamvik, T., Walsh, K., and Myklebust, O. 2000. "Product to Service Eco-innovation: The TRIZ Model of Creativity Explored." In *Proceedings of the 2000 IEEE International Symposium on Electronics and the Environment*, San Francisco, 209-14.

[9] Chen, J. L., and Liu, C. C. 2001. "An Eco-innovative Design Approach Incorporating the TRIZ Method without Contradiction Analysis." *JSPD* 1: 263-72.

[10] Chai, K. H., Zhang, J., and Tan, K. C. 2005. "A TRIZ-based Method for New Service Design." *J Serv. Res.* 8: 48-66.

[11] Lin, C. S., and Su, C. T. 2010. "An Innovative Way to Create New Services: Applying the TRIZ Methodology." *JCIIE* 24: 142-52.

[12] Lari Semnani, B., Far, R. M., Shalipoor, E., and Mohseni, M. 2014. "Using Creative Problem Solving (TRIZ) in Improving the Quality of Hospital Services." *Glob. J Health Sci.* 7: 88.

[13] Michael, L. D., Johnson, D., and Renaghan, L. M. 1999. "Adapting the QFD Approach to Extended Service Transactions." *Prod. Oper. Manag.* 8: 301-17.

[14] Pun, K. F., Chin, K. S., and Lau, H. 2000. "A QFD/Approach for Service Quality Deployment: A Case Study." *MSQ10* 3: 156-70.

[15] Tennant, C., and Roberts, P. A. 2000. "Hoshin Kanri: A Technique for Strategic Quality Management." *Quality Assurance* 8: 77-90.

[16] Tan, K. C., and Pawitra, T. A. 2001. "Integrating SERVQUAL and Kano's Model into QFD for Service Excellence Development." *MSQ* 11: 418-30.

[17] Sakao, T., Watanabe, K., and Shimomura, Y. 2003. "A Method to Support Environmentally Conscious Service Design Using Quality Function Deployment (QFD)." In *Environmentally Conscious Design and Inverse Manufacturing, 2003 (EcoDesign'03.), 2003 3rd International Symposium on IEEE,* 567-74.

[18] Lin, Y., and Pekkarinen, S. 2011. "QFD-based Modular Logistics Service Design." *J Bus Ind. Market* 26: 344-56.

[19] Li, C., Zhe, X., Pei-hua, L., and Ran, T. 2013. "QFD-Based Service Design and Its Application to Library Services System." *Ind. Eng. J.* 4: 24.

[20] Pakdil, F., Kurtulmuşoğlu, F. B., and Yolu, E. 2014. "Improving Service Quality in Highway Passenger Transportation: A Case Study Using Quality Function Deployment." *EJTIR* 14 (4): 375-93.

[21] Kingman-Brundage, J., George, W. R., and Bowen, D. E. 1995. "Service Logic: Achieving Service System Integration." *Int. J Serv. Ind. Manag.* 6: 20-39.

[22] Chuang, P. T. 2007. "Combining Service Blueprint and FMEA for Service Design." *SIJ* 27: 91-104.

[23] Patrício, L., Fisk, R. P., and e Cunha, J. F. 2008. "Designing Multi-interface Service Experiences the Service Experience Blueprint." *J. Serv. Res.* 10: 318-34.

[24] Zehrer, A. 2009. "Service Experience and Service Design: Concepts and Application in Tourism SMEs." *MSQ* 19: 332-49.

[25] Lee, C. H., Wang, Y. H., and Trappey, A. J. 2014. "Service Design for Intelligent Parking Based on Theory of Inventive Problem Solving and Service Blueprint." *Adv. Eng. Inform.* November.

[26] Ellram, L. M., and Siferd, S. P. 1998. "Total Cost of Ownership: A Key Concept in Strategic Cost Management Decisions." *JBL* 19: 55-84.

[27] Taylor, A. P., and Postlethwaite, D. 1996. "Overall Business Impact Assessment (OBIA)." In 4th LCA Case Studies Symposium, Brussels: Society for Environmental Toxicology and Chemistry (SETAC), 181-7.

[28] Kumar, S. B. 2015. "Delivery Management." http://www.researchgate.net/profile/S_Barani_Kumar/publication/271509870_Delivery_Management_in_a_Nutshell/links/54c9f3230cf298fd26274c7c.pdf, Accessed 8 July 2015.

[29] Toigo, J. 2011. *Disaster Recovery Planning: For Computers and Communication Resources.* New York, NY: John Wiley & Sons, Inc.

[30] Damian, D. 2007. "Stakeholders in Global Requirements Engineering: Lessons Learned from Practice." *Software, IEEE* 24 (2): 21-7.

[31] Cooper, D. R., and Schindler, P. S. 2003. "Business Research Methods." http://78.158.56.101/archive/msor/headocs/31businessresearch.pdf, Accessed 8 July 2015, 2003.

[32] Zanakis, S. H., Solomon, A., Wishart, N., and Dublish, S. 1998. "Multi-attribute Decision Making: A Simulation Comparison of Select Methods." *Eur. J Oper. Res.* 107: 507-29.

[33] Hewlett Packard Enterprise Company, Aruba AirWave. http://www.arubanetworks.com/assets/ds/DS_AW.pdf, Accessed 22 June 2017.

[34] ISO/IEC 20000-1:2011 Information Technology—Service Management, http://www.iso.org/iso/catalogue_detail?csnumber=51986, Accessed 29 April 2014.

[35] Kao, Y. C., Chang, Y. C., Peng, S. L., and Chang, R. S. 2016. "A Novel Method for Designing Information Technology Services." In *2016 IEEE International Conference on Computer and Information Technology (CIT)*, 673-80.