A Method for Analyzing Service Failure Causes

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Abstract: The provision of highly reliable services is essential for the maintenance of long-term relationships with customers. To establish highly reliable services, the potential for service failures and their causes must be identified and taken appropriate steps in the process of service design. Methods are proposed to support these activities. However, the quality of these analyses depends on designers' abilities such as their experience. Therefore, it is difficult to enumerate potential service failure and their causes exhaustively in the phase of service design. In this paper, we propose a method for the extraction of service failure causes. The proposed method is verified through its application to a practical case.

Key words: Service engineering; Service reliability; Service Failure causes

1 Introduction

As a society becomes older, service is becoming central to economic growth. Namely, service is an important aspect of many industries. And service is subjected to extensive research in term of many standpoints. According to this background, we have carried out fundamental research on Service Engineering (SE) [1] which aims at providing design methodology of services from an engineering viewpoint.

Providing highly reliable services for customers is important for a company to build or keep long-term relationships with customers and continue to make a profit. In the field of product design, in order to realize highly reliable products, in general, the approach to minimize the occurrence of product failures when customers use their product is widely accepted. It is important to identify the potential product failures and their causes and then, to take them into account in the design phase so as to minimize the occurrence of product failure. For the identification of the product failure and their causes, FMEA (Failure Mode and Effects Analysis) and FTA (Fault Tree Analysis) [2], recognized as effective methods, are applied in various fields as typical engineering methods.

With regard to service field, on the other hand, there are few studies which focus on service reliability from the engineering viewpoint. This is because that it is difficult to evaluate it quantitatively due to its peculiarities such as intangibility or perish ability. Therefore, the engineering evaluation method against service reliability is required [3]. As early research against reliability in service field, FMEA or FTA is applied to services (e.g., [4] and [5]). These proposed methods only provide rough procedure for analyzing service reliability, and therefore, the quality of these analyses depends on designer's abilities such as their experience or subjectivity. Therefore, it's not easy to identify service failures and their causes that have crucial influences on the quality of service. In order to realize highly reliable services, in this study, we aim to propose a method for analyzing service failure that would enable designers to minimize the occurrence of such failures in the service offering. Especially, in this paper, we propose a method that enables designers to extract failure causes without their abilities.

2 A Model of Service Realization Structure in Service Engineering

In Service Engineering, various models are proposed to design and evaluate a service. View model [1], which is one of the models, represents functional service structure. In the view model, the degree of customer satisfaction is represented by a set of Receiver State Parameters (RSPs). RSPs represent the state of customers and functions are constructed hierarchically in order to change the RSP. Each function has a Function Parameter (FP) that means the degree of the exertion of function. The lowest functions in a view model, which have been sufficiently deployed, are related to entities. An entity is something that exists in the real world and it exerts the lowest functions. An entity has one or more attribute parameters (APs). Figure 1 is an example of a view model that describes a part of the realization structure of a coffee shop service. As shown in Figure 1, a view model is expressed visually using a tree structure, and thus allows designers to obtain relationships among a RSP, function and actual entities.

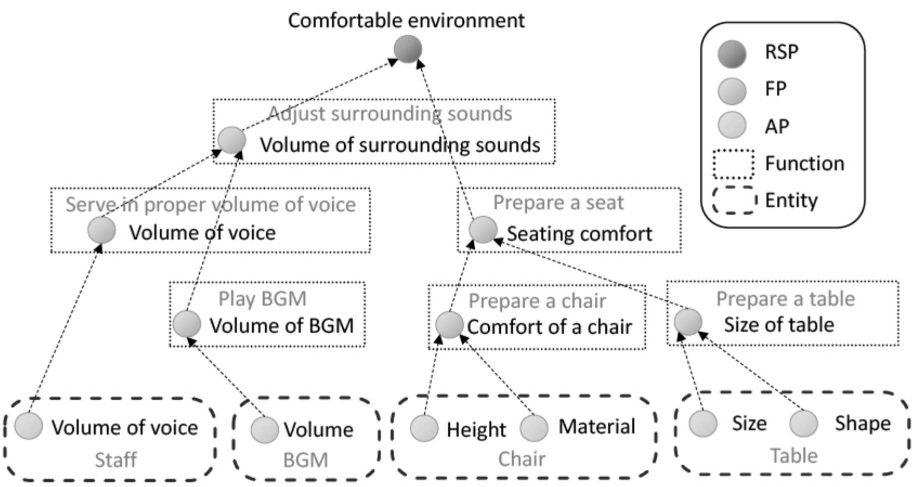

Figure 1 View model of a coffee shop service

3 Product and Service Failure

3.1 Product failure

According to the International Electrotechnical Commission (IEC), failure is defined as "the termination of the ability of an item to perform a required function" [6]. The word "item" refers to any part, component, device, subsystem, or functional unit. Many methods, with FMEA at the head of the list, are proposed for analyzing "failure" as defined above. On the other hand, there is the ontology of faults [7] as one of effective concept which enables us to specify the performances of the models in diagnostic systems. It is a conceptual system which aims to explicate the capabilities of model-based diagnostic systems and to realize reasoning mechanism and stepwise reasoning. It clarifies the concept of faults by means of a classification of fault processes, resultant states, and causes. This ontology enables designers to examine the causes of faults exhaustively because it includes various concepts from a variety of viewpoints. In addition, it's not only effective in specifying functional causes but also enables us to specify physical causes which based on physical relationships such as time axis.

3.2 Service failure

Few studies have defied service failure precisely, since the recognition against service failure is different due to the field of study. This study assumes that fundamental interpretation against product failure and service failure is not essentially different, since service can be regard as artifacts created by human beings. Consequently, in this study, the definition of "failure" as defined by IEC above is applied to services. In this case, the difference between product failure and service failure is the way of understanding against "item". In product field, as stated above, "item" which defined by IEC only means any part, component and device etc. However, in service field, human beings also should be included in "item" because they are quite important element of service and the quality of service depends on the performance of them. Human beings here include both service providers and customers. As a peculiarity of service, customers participate in production process directly, and therefore, a customer behavior has a harmful influence on the whole quality of service. These customers' behavior can be regard as service failure. As explained above, in service failure, there are many failures due to the interaction between human being and human being or human beings and systems compared to product failure. Based on these, in this study, service failure is recognized as "the termination of ability of a service component to perform a function which intended by a designer". The word "service component" refers to human beings, artifacts and systems. And the state of failure is called the failure mode.

The structure of Figure 2 illustrates the manner in which service failures occur. The front stage is the location where a service provider actually provides his services to customers. A clinical examination in a doctor's office is an example of front stage. The back stage for providers is the location where providers' activities that customers cannot see take place, e.g., the management of medical records. On the other hand, the back stage for customers is the location where customers' activities that providers cannot see take place, e.g., customers take their medicine at home. An ideal is to comprehend service failures which occur in these locations exhaustively in the process of service design. However, in this study, the scope of analysis includes the service provider's front stage and back stage.

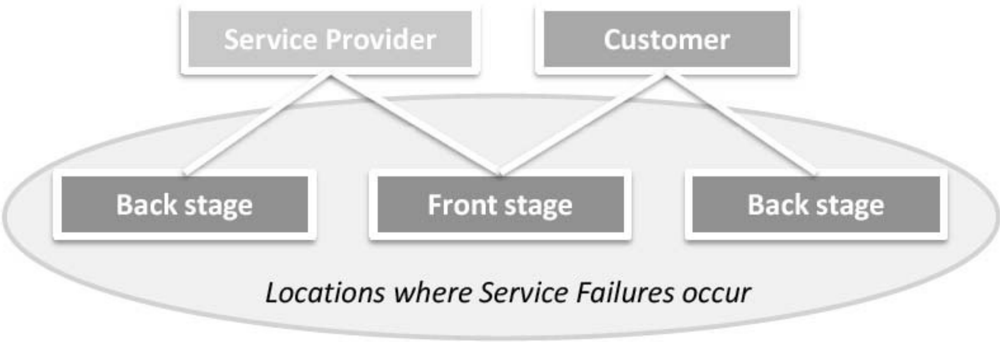

Figure 2 Location where service failures could occur

4 A Method for Analyzing Service Failure Causes

4.1 A template for extracting service failure causes

In general, the number and quality of extracted failure causes by designers depends on their abilities such as experience. Designers use "knowledge with regard to failure" and "estimate ability" when they assume failure causes[8]. Therefore, it is effective to supporting these abilities so as to enhance the quality of extracted failure causes. If supporting "knowledge with regard to failure", knowledge database is one of effective means because it enables designers to reuse knowledge regarding failure. If supporting "estimate ability", providing multilateral viewpoints to them is one of valid approach. In this study, we aim at supporting "estimate ability" of designers when they assume service failure causes. Specifically, as viewpoints of extracting service failure causes, we apply a classification of causes such as "time", "result" and "cause" proposed in the ontology of faults as stated above to services. In other words, it is possible to decrease the dependence on designers' abilities when a designer extracts them by giving comprehensive points of view against "estimate ability" of designers. Figure 3 shows detailed viewpoints of extracting service failure causes and the structure of them.

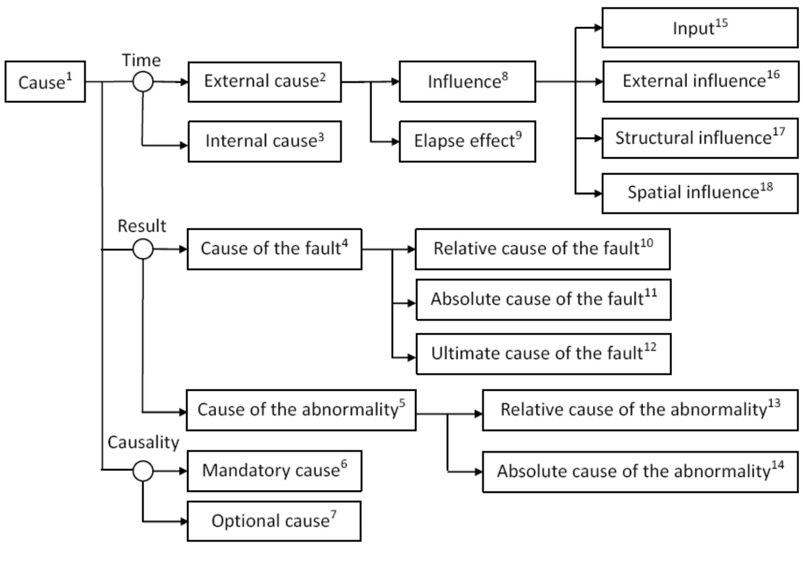

Figure 3 The viewpoint of extracting service failure causes

In the following, we explain each viewpoint as shown in Figure 3 in detail.

(1) The viewpoint in “Time”

“Time” in Figure 3 means a point in time when one service component transition to a state of failure. A cause1 (this superscript corresponds to Figure 3) of the transition to is, in general, influence8 which is carried from the outside. Influence8 is divided into input15 and external influence16 according to if it is intended or not by designer. If it is intended by designers, it is called input15. And if it is not intended by designers, it is called external influence16. For example, an objection in a restaurant service can be understood as input15 because recently, how to deal with objections is standardized. On the other hand, a word of mouth can be external influence16 if it exerts unfavorable influence on the whole service. Because, in general, designers cannot assume what kinds of a word of mouth could occur in their service. In addition to perspective regarding intention, according to the way of influencing, it is further divided into structural influence17 and spatial influence18. The above word of mouth is spread across other customers spatially, namely it is understood as spatial influence18. If one employee exerts a harmful influence to other employees and then, the quality of service becomes lower, it is structural influence17 because the relations between employees are, in general, structural connection. A cause1 of the state change of a service component not only includes influence8 from outside but also elapse effect9. The latter represents an event which naturally happens as time passes such as quality fading. In service, a simple mistake such as a mistaken order by employee is included in elapse effect9. The above all causes happen in a service when providing. But other kind of causes is already involved before service offering. According to this viewpoint, cause1 is divided into external cause2 which occur in service offering and internal cause3 which is already involved in the phase of service design. An example of the latter is the defects in an operating manual in restaurant services.

(2) The viewpoint in “Result”

A cause1 of irreversible state change is called cause of the fault4. A cause1 of irreversible state change means that a service component cannot return to the original condition even if harmful influence on it is excluded. In general, product failures correspond to this, since most product failures cannot return to the condition that before each failure. And cause of the fault4 is represented by a triple, <relative cause of the fault10, absolute cause of the fault11 and ultimate cause of the fault12>. For example, in the case of “elapse effect” and “continuous operation beyond a permissible amount” are assumed as failure causes of dishwashing machine in a restaurant service, the latter can be understood which has further upstream cause, namely, the latter corresponds to relative cause of the fault10. On the other hand, the former is absolute cause of the fault11 because it is the uppermost cause which cannot go upstream any further. In general, absolute cause of the fault11 is elapse effect 9or influence from outside of the target service. In the case of the latter, there aren’t any upper causes in the intended model, however further upstream causes could exist in the real world. Therefore, these are called ultimate cause of the fault12.

On the other hand, a cause of reversible state change is called cause of the abnormality5. A cause1 of reversible state change means that a service component can return to the original condition if harmful influence on it is excluded. In this study, failures regarding human being in service correspond to this, since the internal state of human being is changed temporarily due to influence from outside, namely its functions are recovered when harmful influence on it is excluded. And cause of the abnormality5 is also divided into relative cause of the abnormality13 and absolute cause of the abnormality14.

(3) The viewpoint in "Causality"

Causality in Figure 3 is divided into mandatory cause6 and optional cause7. Mandatory cause6 is a cause that the state change of service component never happens if this cause doesn't exist. Optional cause is a cause which accelerates a state change. This cause doesn't influence on whether transition to the state of failure or not.

Table 1 shows a template for the extraction of service failure causes that includes the viewpoints noted above. This template provides multilateral points of view to designers.

Failure mode	Time						Result					Causality	
	External cause					Internal cause	Cause of the fault			Cause of the abnormality		Mandatory cause	Optional cause
	Influence				Elapse effect								
	Input	External influence	Structural influence	Spatial influence			Relative cause	Absolute cause	Ultimate cause	Relative cause	Absolute cause		

4.2 A procedure for analyzing service failure causes

The method to extract service failure causes using the template as shown in Table 1 consists of the following three steps.

Step1: Description of view model

Designers determine the realization structure of target service and areas of analysis by describing the view model. In the view model, customer behavior is not described because, as reported in 3.2, our scope of analysis is service provider's front stage and back stage and customer's front stage is not included.

Step 2: Extraction of service failure modes

In this study, service failure is understood as "the termination of ability of a service component to perform a function which intended by a designer". A service failure mode which is a state of service failure corresponds to a state that a lowest function in view model cannot exert its function, since the lowest functions in view model represent functions that entities exert. Therefore, negative expressions of lowest functions in view model which described at Step 1 are extracted as service failure modes.

Step 3: Deployment of the template for the extraction of service failure causes

In this step, designers deploy to service failure causes extraction template as shown in Table 1. Specifically, designers deploy service failure modes to leftmost column of the template at first, and then extract service failure causes from viewpoints as shown in Figure 3 against each service failure mode. It is possible to decrease the dependence on designers' ability when extracting service failure causes by means of these three steps.

5 Verification

5.1 The contents of verification

The proposed method was applied to gas station service. In this verification, four test subjects participated. Two had experience as service providers. The other two were experienced service receivers. The content of this verification was that test subjects completed "Step 3:

Deployment of service failure causes extraction template". We were able to determine whether or not the dependence on designers' experience is reduced.

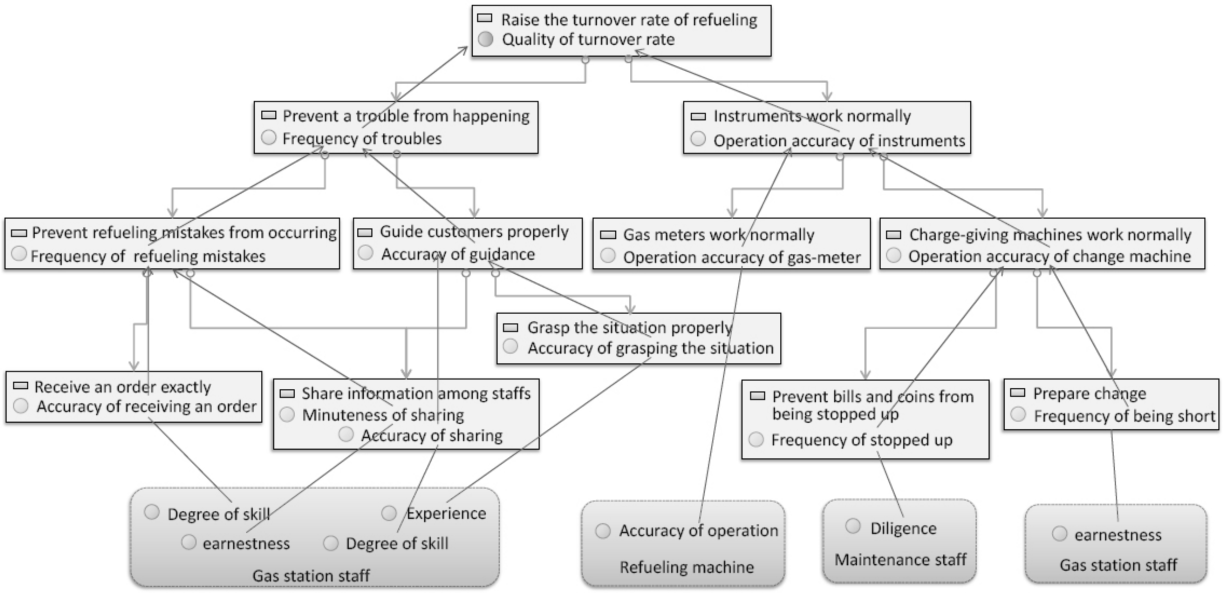

Figure 4 A View model for "Quality of turnover rate for refueling"

Table 2 Some of extracted service failure modes

Entity	The lowest function	Failure mode
Gas station staff	Receive an order exactly	An order is not received exactly
	Share information among staffs	Information is not shared among staffs
	Grasp the situation properly	the situation is not grasped properly
	Prepare change	Change is not prepared for customers
Gas meter	Work its function normally	The state that gas meters don't work normally
Maintenance staff (Charge-giving machine)	Prevent bills and coins from being stopped up	Being stopped up with bills or coins

First of all, we configured "Quality of turnover rate for refueling" and "Quality of work" as RSPs, and then described view models based on above two RSPs (Step 1). As results, two view models are described in Step 1. One view model for "Quality of turnover rate for refueling" is shown in Figure 4. After that, negative expressions of lowest functions in two view models were extracted as service failure modes (Step 2). Table 2 shows a part of extracted service failure modes from two view models and the process of extraction. For example, negative expression of "prevent bills and coins from being stopped up" was "being stopped up with bills and coins". And it is extracted as a failure mode.

5.2 The Results of Verification

Service failure causes extraction template is deployed by four test subjects (Step 3). Some of the verification results are shown in Table 3.

Table 3 Some of the verification results

Failure Mode	Time					Result			
	External cause				Internal cause	Cause of the fault		Cause of the abnorm	
	Influence			Elapse effect					
	Input	External influence	Structural Influence			Relative cause	Absolute cause	Relative cause	Absol caus
Information is not shared among staffs	・lack of communication ability ・fail to convey information ・congestion	・customer's erroneous order ・unexpected congestion	・staff's erroneous order ・be estranged between staffs ・coercive behavior ・foreign staff ・languid behavior	・fail to repetition ・fail to information sharing ・a lot of newcomers	・less-education ・defect working schedule	・less-education against newcomers	・shortage of manpower	・quiet voice	
The situation is not grasped properly	・...cannot grasp fill opening ・...cannot grasp the order of customers ・congestion ・absent leader	・an objection ・unexpected congestion ・inapprpriate geometry of lights	・lack of information sharing ・lack of combination	・lack of attention ・a lot of newcomers	・structural defect of gas station ・inappropriate geometry of refueling aircraft ・lack of experience	・shortage of manpower	・inappropriate geometry of refueling aircraft		
Being stopped up with bills and coins	・diffusion cash card ・forget filling up	・increase exchange ・unexpected congestion ・payment with bills			・stock shortage ・shortage of staff who can filling up ・lack of machine ability	・cannnot express "near empty"	・stock shortage ・shortage of staff who can filling up	・stock shortage	
A staff cannot attend to customer with liability	・lack of liability ・disinclination for sales of goods ・no penalty	・interruption of other work	・have poor support		・inappropriate way of education ・lack of knowledge ・uncertainness of liability	・shortage of manpower	・lack of liability ・defect in educational manual		
A staff doesn't communicate with customers	・lack of communication ability ・lose motivation ・congestion	・lack of customer's communication ability ・increase orders ・customer speaks foreign language		・serve with prejudice ・negligence ・shortage of	・...doesn't understand necessity ・there is no support manual		・shortage of manpower ・lack of knowledge	・exhaustion	

Table 4 Number and average of extracted Service Failure Causes

Failure mode	Test subject					
	Experienced person			Inexperienced person		
	a	b	Ave.	c	d	Ave.
Information is not shared among staffs	9	9	9	5	9	7
The situation is not grasped properly	9	8	8.5	5	7	6
A state that gas meters don’t work normally	3	4	3.5	4	4	4
Being stopped up with Bills and coins	4	5	4.5	4	5	4.5
Change is not prepared for customers	4	5	4.5	4	6	5
A staff cannot attend to a customer with liability	8	6	7	8	5	6.5
A staff doesn’t communicate with a customer	8	7	7.5	9	8	8.5
A staff doesn’t have a desire to improve himself	7	8	7.5	5	8	6.5
Study meeting cannot be held	4	4	4	3	4	3.5
Part-time job staff cannot do easy work	8	6	7	6	6	6
Work schedule is not created properly	3	4	3.5	4	3	3.5

Table 3 consists of verification results of both one person who has experience as a service provider and one person doesn't have experience as a service provider, but as a customer. The results obtained by the experienced person are shown in blue. The results of inexperienced person are shown in red. As shown red in Table 3, proposed template enables inexperienced persons to extract service failure causes form various points of view. Experienced person extracted "the structural defect of gas station" as failure cause against failure mode "The situation is not grasped properly". On the other hand, inexperienced person extracted "the inappropriate geometry of refueling aircraft" as failure cause. As shown these results, inexperienced person can extract service failure cause which is almost same quality of experienced person.

Table 4 shows the number of extracted service failure causes by experienced persons and inexperienced persons using the template and the average of them.

Compared to each average in Table 4, almost the same number of service failure causes is extracted by four test subjects. Inexperienced persons extracted them more than experienced persons with regard to service failure mode "A staff doesn't communicate with a customer". On the other hand, experienced persons extracted them more than non-experienced persons with regard to service failure mode "Information is not shared among staffs".

6 Discussion

As shown in Table 4, even if a designer doesn't have experience as service provider, they can extract almost the same number of service failure modes compared to experienced persons by means of the template. Namely, the extraction of service failure causes which can reduce the dependence on designers' experience is realized by using the proposed template. On the other hand, as shown in Table 3, the failure cause "the inappropriate geometry of refueling aircraft" which is extracted by inexperienced person with regard to the failure mode "The situation is not grasped properly" corresponds to some viewpoints such as external influence16 and internal cause3. That is to say, one failure cause corresponds to multiple viewpoints. Therefore, a certain level of procedure to extract failure causes is required. An idea of a certain level of procedure is extracting them from internal cause3 as first step because some failure causes which extracted from viewpoint of internal cause3 analogized to APs in the view model. The other idea is making up for the leakage of extraction gradually by means of certain precedence on triple viewpoints.

In Table 4, the both averages of experienced persons and inexperienced persons are almost the same number. However, there was the difference in the number of failure causes between experienced persons and inexperienced persons with regard to failure modes "Information is not shared among staffs" and "The situation is not grasped properly". This result can be generated by the difference of experience or knowledge on job site. Designers use two abilities "knowledge with regard to failure" and "estimate ability" when they assume failure causes. The difference of experience or knowledge is decreased by supporting the former ability, but, in this study, we aim to support the latter ability. Namely, our method cannot support the former ability at present. This is why the difference existed. Consequently, in order to support the former ability, for example, the construction of data base which enables designers to refer to past cases is one of countermeasures.

On the other hand, designers cannot grasp the relationship among failure causes from proposed template, since the template only provides multilateral viewpoints to designers. And the particle size of extracted failure causes is not maintained constant. According to these, there is no guideline such as which failure causes should be taken the appropriate steps, namely the priority sequence of failure causes. The concept of Fault Tree in FTA [2] is effective with regard to relationships among them and the particle size of them. That is to say, tree structure such as Fault Tree makes the particle size of failure causes consist and relationships among them would be clear. On the other hand, regarding the priority sequence of failure causes, to introduce evaluation axis such as RPN (Risk Priority Number) in FMEA [2] is one of countermeasures.

7 Conclusions

In this paper, our aim was to propose an extraction procedure of service failure causes which doesn't depend on designers' abilities such as their experience so as to enhance the accuracy of analysis. We proposed a method for analyzing service failure causes that reduces the dependence on the ability of designers. Specifically, we proposed a template for the extraction of service failure causes which provides multilateral viewpoint to designers and a procedure of extracting them using the template. The proposed method is applied to a gas station service. And our verification results confirmed the effectiveness of our method. Future works include refining a procedure of extracting failure causes and considering how to determine the priority sequence of them.

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