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IMPROVING MOBILE SERVICES DESIGN: A QFD APPROACH

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Abstract. The quality of mobile services in the mobile and wireless world is ultimately judged in terms of customer satisfaction. This is particularly true for the third generation (3G) and beyond multimedia mobile services which should meet or exceed customer expectations. In this study Quality Function Deployment (QFD) is used for the first time as a quality improvement approach for building customers' requirements into mobile services. Traditionally QFD approach is adopted in product and manufacturing industries. In this paper QFD is extended to mobile service industry which is such a promising industry in today's information society. This paper proposes a generic framework based on QFD concepts and practices to improve mobile service design and development. An example is presented to illustrate the use of QFD for mobile e-learning services for university students and lecturers. The data transmission speed is found to be the most critical requirement in mobile e-learning services. By the use of QFD the developed mobile services can best meet customers' requirements or even exceed their expectations. At the end of this paper some benefits as well as further improvements regarding QFD approach are discussed and concluded.

Keywords: Mobile service, e-learning, quality function deployment, customer requirement, voice of customer, house of quality

1 INTRODUCTION

In today's information society the whole world is going wireless and mobile. People would like to be connected anywhere and anytime. As a result, the mobile services industry is growing fast thanks to the advanced information and communication technologies. With current mobile technologies people can remotely control home appliances, enable real-time visual communications, and make electronic payments through a mobile phone. In the coming years more and more exciting 3G and beyond multimedia mobile services will come true. According to Europe's eMobility Technology Platform (`http://www.emobility.eu.org`), today, more than 2.8 million jobs depend directly or indirectly on the mobile services industry in the EU Member States. However, a key challenge in mobile services industry is how to design and develop high quality mobile services which means how to satisfy end customers or even to exceed their expectations? For this we need quality improving methodologies and technologies to be used in mobile services industry. One of the most powerful quality improving methodologies is the Quality Function Deployment (QFD).

QFD is a customer-driven tool in implementing total quality management (TQM) [1]. It is an overall concept that provides a means of translating customer requirements into the appropriate technical requirements for each stage of product development and production [2]. QFD is also defined as a quality-based method for increasing customer satisfaction and value with products and services by translating the Voice of Customer (VOC) into design specifications and implementation instructions, ensuring that the organization will carry them out and give customers what they will pay for. Its power lies in the fact that it lays bare an organization's processes and how these processes interact to create customer satisfaction and profit [3]. The Japanese view QFD as a philosophy that ensures high product quality from the design stage. The aim is to satisfy the customer by ensuring quality at each stage of the product development process [4].

QFD can be credited to Professor Mizuno; it was introduced in the early 1970s to help design supertankers in Mitsubishi's shipyards in Kobe, Japan. Its original Japanese designation comes from *hin shitsu ki no ten kai*, a phrase coined by Dr. Yoji Akao in the 1960s [5]. Literally, it can be translated as:

hin shitsu – Quality, attributes or features

ki no – Function or mechanization

ten kai – Deployment, diffusion, development [6, 7]

Since Dr. Akao's paper on QFD at a conference in Chicago in 1983, many industries have disseminated the method and a large number of research articles and books have been published on the use of benefits of QFD.

QFD has been widely applied in the products and manufacturing industries, for example machine building, consumer products, food and beverage, automobile and aerospace industries etc. In the early 1990s QFD techniques were adopted by US firms to reduce time to market, decrease costs of design and manufacture, and increase overall product quality. Today's successful product-oriented companies are focusing on these three main goals to improve their competitive advantage [8, 9].

However, QFD can also be extended to service industries which include, among others, airlines, resort hotels, education and healthcare services. The processes of quality assurance and product design present unique challenges when applied to services [10, 11, 12]. This is particularly true for mobile services, for a single 'product' is made up of physical goods while mobile services are embedded within a series of discrete consumption and interaction experiences. Recently there are a few articles with the application of QFD in the service industries. For example a QFD system for police services was implemented at a federal police station in Belgium in order to match better the demands and needs of the general public and authorities to the activities deployed by the police station [13]. RainStar University in US has adopted QFD to construct a higher education curriculum to ensure that its curriculum could be analyzed critically and remain responsive to change in order to meet the needs of the real world [14]. A more recent paper applies QFD to enhance nursing home service quality. The author identified the first two areas requiring improvement in nursing organizations which are the speed to handle the emergency and the recruitment of specialized medical personnel [15].

However, QFD has not so far been deployed in the mobile services industry. In this paper a generic QFD framework is proposed for implementation for mobile services design and development. An example is presented to illustrate the use of QFD for mobile e-learning services for university students and lecturers. A number of conclusions are made and future work is outlined at the end of this paper.

2 THE QFD PROCESS

In the mobile services industry the QFD approach can be implemented throughout mobile services design and development stages. A generic framework for application of QFD in the mobile services industry is given in Figure 1.

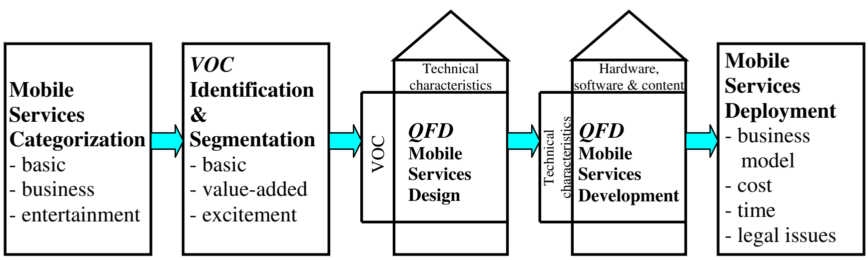

Fig. 1. The generic framework for QFD application in mobile services industry

In Figure 1 there are five stages for mobile services development and deployment process. The five stages are explained in detail as follows:

Mobile services categorization: The first stage means before designing a new mobile service it should be clear what this service is intended for, or what the purpose of this service is? Is it for entertainment purpose such as mobile gaming or it's a mobile service for business purpose, for example mobile office for database retrieving, or it simply provides a basic service, for example remote control of home appliances outside home. The nature of the service itself will in a way determine the customer requirements for this service.

VOC identification and segmentation: During the second stage the voice of customers must be carefully listened to, both spoken and unspoken wants and needs should be identified. This is usually through different survey methodologies such as paper questionnaire, telephone interview, brainstorming etc. The various customer requirements for mobile services will be further classified as basic functions, value-added functions, and excitement functions. The basic functions are must-be functions because it will lead to immediate customer dissatisfaction without these basic functions. The value-added functions are those functions which can bring more satisfaction, the more value-added functions the more satisfaction customers have. The excitement functions are functions which are basically not expected by customers. With the addition of excitement functions customers' satisfaction will be dramatically enhanced.

QFD mobile services design: The QFD approach is formally employed at this stage for building VOC into technical characteristics or requirements of mobile services for implementation. This stage is called House of Quality (HOQ) building and the detailed process will be described in the following sections. The technical characteristics are weighed and prioritized and serve as inputs for next HOQ of mobile services development.

QFD mobile services Development: After the QFD mobile services design stage it comes up with the service development stage. At this stage the weighed mobile services technical characteristics are linked with mobile services hardware, software and service content providers. This stage is for real service development.

The last stage is mobile services deployment. How and where to implement the developed mobile services? How fast should the service be brought to the market? What's the charging scheme for the service? What's the government regulation for this type of mobile services? These are some of the questions which must be answered in the deployment stage. The mobile services deployment stage plays a special role in a timely and successful implementation of mobile services.

2.1 The Voice of Customer

The VOC represents customer requirements for mobile services. There are different ways to collect VOC, for example through questionnaire, literature survey, and interviews with field experts. After identification of the customer requirements for mobile services the next task is to weigh and prioritize these requirements. In this paper we have segmented customer requirements into three groups, namely *basic*, *value-added*, and *excitement*. The basic requirements are the mobile service functions for successful service performance itself and minimum customer satisfaction. For example the text on a mobile device screen should be clear enough for read and navigation purpose. The value-added functions are those functions which can bring more satisfaction, for example the usage of colorful and animated text on display will usually delight customers. The excitement functions are functions which are basically not expected by the customers and customers are unaware of what they are missing. The addition of these functions will enhance customer satisfaction to a great extent. These functions can be called "killer service" functions or requirements.

The purpose of segmentation of customer requirements is to treat them differently in weighing the importance of these requirements. Customer requirements are not equal in terms of customer satisfaction. Some requirements are more important to the customer than others and some are important to the customer in different ways than others. In practice we can adjust the importance ratio in calculation of weights in QFD. For example the following approximate transformation function can be derived for the adjusted importance ratio [16].

$$IR_{adj} = (IR_0)^{1/k}$$

Here IR_{adj} is the adjusted importance ratio and IR_0 is the original importance ratio and k is the importance parameter for different customer requirements. For example we can choose $\frac{1}{2}$, 1 and 2 for basic, value-added, and excitement customer requirements, respectively. Therefore, the importance ratio can be adjusted using the above equation.

2.2 The House of Quality

The House of Quality is the primary planning tool in the QFD approach. It is a conceptual map that provides the means for interfunctional planning and communication of customer requirements and technical responses. In the HOQ, the relative weights of customer requirements are obtained from the customer themselves. The question 'How important is the requirement to the customer?' is answered directly by market research. Here, the customers need not make pairwise comparisons but are asked to give each requirement a number expressing relative importance according to their own considerations and criteria; this is the basis of the prioritization matrix method in the HOQ. The steps to build the HOQ are:

- list customer requirements (whats),
- list technical characteristics (hows),
- develop a relationship matrix between whats and hows,
- develop an interrelationship matrix between hows,

- develop prioritized customer requirements,
- develop prioritized technical characteristics.

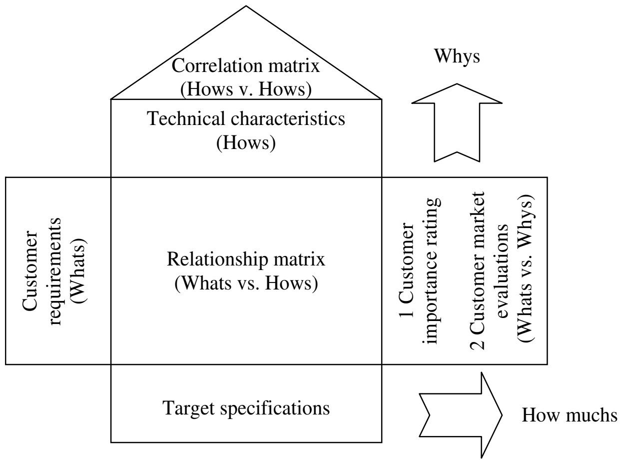

Fig. 2. The house of quality model

A HOQ model is illustrated in Figure 2. In the figure the collected customer requirements are located at the left side of the HOQ while the corresponding technical characteristics are on the top of the HOQ. The roof of the HOQ is a correlation matrix which examines the interrelationships between various technical characteristics. The right side is the customer importance rating for identified customer requirements. The bottom is the target specifications, i.e. the prioritized technical characteristics. In the middle it is the relationship matrix between pairs of customer requirements and technical responses and 1-3-9 or 1-3-5 scale is used to denote weak, medium and strong relationships. A detailed example of HOQ building will be given in the following section.

3 DESIGNING MOBILE E-LEARNING SERVICES THROUGH QFD: A CASE STUDY

The University of Oulu is currently designing mobile e-learning services for university students. The project aims to carry out research and develop e-learning web services as well as electronic classroom teaching based on innovative mobile instant learning technologies and tools and e-learning methodology and scenarios appropriate to a community of e-learning students in northern Finland. One application of e-learning services is to have access to daily classroom lectures through handset mobile terminals such as mobile phones or dedicated personal digital assistants (PDAs) or computers. This way students from different locations in the country may participate the lecture, ask questions to the lecturer through the use of mobile terminals, even when they are on the move. Currently this e-learning service is being developed in the university as shown in Figure 3. Students and lecturers are connected through classroom computer servers and individual mobile terminals. Both students and lecturers can actively participate discussions and the current active speaker will have a face shot on the display. In order to design such a mobile e-learning service a QFD approach is adopted to best meet the wants and needs of customers, i.e. students and lecturers of the university.

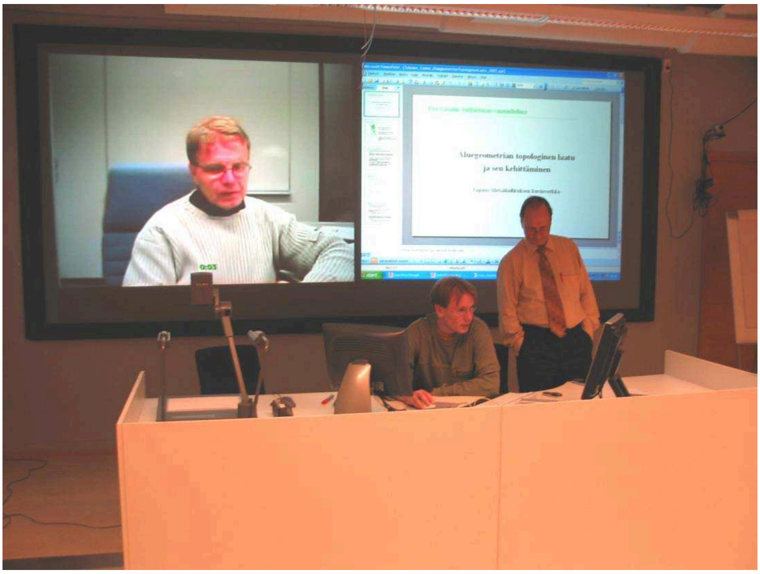

Fig. 3. A mobile e-learning service scenario

3.1 Identification of VOC

In order to identify customer requirements for this mobile e-learning service an interview was performed among university students and lecturers. A number of students and lecturers were interviewed in this study. The students and lecturers are from different departments of the university including IT department, economics department, medical department, education department, and language department. All of them have some e-learning experience. The interviewees are also asked for the degree of importance for the mentioned requirements. From the interviews six most important customer requirements are identified and they are classified into the three segmentations of VOC as shown in Table 1.

In Table 1 the six most important requirements for mobile e-learning service are categorized into basic, value-added, and excitement groups. High quality images and

VOC segmentation	Customer requirements for mobile e-learning
Basic	(1) High quality images (2) No delay of sound
Value-added	(1) Easy mobile access (2) Easy to navigate
Excitement	(1) Attractive user interface (2) Innovative interaction and animation

Table 1. VOC Segmentation for mobile e-learning service

no sound delay are the two basic requirements. Most interviewees mentioned the high quality sound requirement and it will be annoying if there is some sound delay. The images and sound requirements are basic requirements for mobile e-learning. For value-added group there are two requirements, i.e. easy mobile access and easy to navigate. The e-learning classroom should be easily accessed from mobile terminals or computers. The navigation operation should also be easy, for example the function menu should be clear and easy to understand. For excitement group the interviewees mentioned attractive user interface and innovative interaction and animation. All these functions will make them feel excited and thus have more interest to participate in the e-learning process.

3.2 Identification of Technical Characteristics

In order to identify technical characteristics a group of research engineers participated in a brainstorming to locate the most important technical characteristics for meeting the customer requirements. Seven technical characteristics are identified, i.e. network coverage, data transmission speed, display resolution, terminal costs, network access cost per time unit, terminal size and weight, and power consumption. These technical characteristics or requirements reflect the practical technical descriptions from design engineers' point of view. The customer requirements and technical characteristics are linked in the following HOQ.

3.3 The House of Quality for Mobile e-Learning

The House of Quality is illustrated in Figure 4 without the correlation matrix for simplicity. The six customer requirements are on the left of the HOQ and the seven technical characteristics are on the top of the HOQ. In this example we simply use number 5 to represent the highest rating, indicating strong importance of high quality images for mobile e-learning. In the current mobile e-learning service the *high quality images* is only ranked 2 on a scale from one to five. This is obviously not competitive. The competitors X and Y are ranked 3 and 2 respectively on *high*

WHATs vs. HOWs

Strong relationship ● 9
Medium relationship O 3
Weak relationship △ 1

TECH QUALITY CHARACTERISTICS	Network coverage	Data transmission speed	Display resolution	Terminal costs	Network access cost per time unit	Terminal size and weight	Power consumption	Customer importance rating (1)	Competitive position	Our current e-learning service (2)	Competitor X	Competitor Y	Plan (3)	Improvement ratio (4) (4)= (3)/(2)	Sales point (5)	Absolute weight (6) (6) = (1)x(4)x(5)	Demanded quality weight (7)=(6)/sum(6)
DEMANDED QUALITY																	
High quality images	O	O	●			O		5		2	3	2	5	2.5	1.5	18.7	67.6
No delay of sound	△	●					△	4		3	2	3	4	1.3	1.2	6.4	49.4
Easy mobile access	●	O			O	△	O	3		4	3	2	4	1	1.2	3.6	40.9
Easy to navigate		O	O			O		3		4	3	4	4	1	1.5	4.5	45
Attractive user interface			△	O		O		4		3	4	3	4	1.3	1.0	5.2	45.2
Innovative interaction		●	△				△	5		3	2	2	5	1.7	1.5	12.8	61
Absolute weight	611	1454	850	136	123	514	233										
Quality characteristic weight	15.6	37.1	21.7	3.5	3.1	13.1	6.0										
Competitive benchmark																	
Our current service	500	256	512	100	10	50	800										
Competitor X	600	128	512	150	8	75	1200										
Competitor Y	400	64	256	90	12	90	1500										
Target specifications	1000	2M	1024	70	5	50	500										
Unit	km	Kb/s	pxl	Tcost. K$	Ncost $/Unit	Weight Kg	Watt										

Fig. 4. The house of quality for mobile e-learning service (without the correlation matrix)

quality images. The competitors are also not good on this point, hence an opportunity arises to increase the rank from 2 to 5 for *high quality images* and a plan is set.

The improvement ratio, meaning the degree of improvement, is calculated by dividing the plan by the current service performance, i.e. $5/2 = 2.5$. The improvement ratio can be adjusted by using the k parameter as shown in the equation $IR_{adj} = (IR_0)^{1/k}$. The k parameter can be decided by the service designer. Sales points reflect the vision of the designer on various quality items and are given values as 1 (weak), 1.2 (moderate) and 1.5 (strong). The absolute weight is calculated by multiplying the customer importance rating $\times$ improvement ratio $\times$ sales points, for *high quality images* we get $5 \times 2.5 \times 1.5 = 18.75$. At last the demanded quality weight is calculated by normalizing the absolute weights to a percentage. $18.75 \div (18.75 + 5 + 2.5 + 1.5) = 67.6\,\%$. The demanded quality weight indicates the criticality of *high quality images* based on importance to the customer, competitive position and designer vision.

After obtaining the demanded quality weights we now can convert them to technical quality characteristic weights in order to focus design activity on the most critical characteristic. The relationship between *demanded quality* and *quality characteristics* is assigned a value based on a 1-3-9 scale where 9 represents the strong relationship. Each demanded quality weight is then multiplied by the relationship value in cells in its row. The products in each column are summed to give an absolute weight. For *data transmission speed*, multiply the demanded weight: $67.6 \times 3 = 202.8$, $49.4 \times 9 = 444.6$, $40.9 \times 3 = 122.7$, $45 \times 3 = 135$, $61 \times 9 = 549$. Sum, $202.8 + 444.6 + 122.7 + 135 + 549 = 1\,454$. Normalizing it to a percentage we get a quality characteristic weight of 37.1 %. This means based on customer importance, competitive position and designer vision, 37.1 % of the mobile e-learning design focus should be put on *data transmission speed*. For example a target specification 2 Mb/s is selected for the *data transmission speed* instead of our current 256 kb/s. The designer can then select or develop appropriate mobile technology and mobile terminal to achieve this target. A new HOQ can be built for this purpose during the next QFD mobile services development stage. Hardware, software and service content creation should be developed at this stage. As a result the mobile e-learning service will best meet the needs of university students and lecturers in the information society.

4 DISCUSSIONS

In this example we developed a HOQ for mobile e-learning service for university students and lecturers. The developed service will best meet the user requirements. In this example the correlation matrix is excluded for simplicity. There are some disadvantages in the QFD approach, for example the requirements importance rating is usually subjective. For this we need more quantitative methods to weigh and quantify the importance rating. The QFD approach can also be implemented further for the mobile services development stage where hardware, software, and service content creation will need to be specified or developed. The inputs at this stage are the prioritized technical characteristics. The last stage is the mobile services deployment stage to bring the service to the market. For this the business model, charging scheme, time frame, and government regulations must be carefully considered.

However, one of the most creative QFD applications is to use "House of Quality" matrix to perform a rigorous cost benefit analysis. The magnitude of final weight numbers from QFD calculations represents the relative importance of each of the quality characteristics, i.e., the benefit to be gained from moving that quality characteristic significantly in the desired direction.

The true cost-benefit analysis comes up with the simple calculation of the ratio of that benefit vs. the associated cost. The units can be in the form of "benefit points per thousand dollars". It will help the mobile service development team weigh exactly which quality characteristics are most deserving of their limited service development dollars and which to avoid, taking into account the tough technological problems etc. For example, suppose that one quality characteristic, if improved upon, would deliver 8 000 of these "benefit points", but would cost $ 4 m and 2 years of design work to deliver. Another far less important quality characteristic would only deliver 1 500 "benefit points", but could be done for $ 500 k and only 6 months to complete. The ratios (2.0 vs. 3.0) tell a far different story than the "benefit points" alone (8 000 vs. 1 500) and will help the service team weigh the trade-offs and prioritise their efforts.

With the aid of QFD cost analysis for both mobile service providers and potential service users, the mobile service design and development team can determine which quality characteristics should be included in the first version of the service and which to be included in subsequent generation mobile services. The results will be the cost and time effective mobile services that best satisfy both mobile service providers and service users.

5 CONCLUSION

This paper proposes a generic framework based on QFD concepts and practices to improve mobile service design and development. An example is presented to illustrate the use of QFD for mobile e-learning services for university students and lecturers. The data transmission speed is found to be the most critical requirement in mobile e-learning services. By the use of QFD the developed mobile services can best meet customers' requirements or even exceed customer expectations. It is strongly believed that mobile service design cost and design time will be significantly reduced while mobile service quality will be greatly improved by using QFD approach due to its systematic linking of customer requirements into and throughout the entire design, development, and implementation process.

Further QFD research work on mobile service is well under the way. We are including the correlation matrix in building the HOQ for typical mobile services. A quantitative approach is being developed to quantify customer requirements importance. Future research results will include several case studies in mobile services design, development, cost analysis and a more detailed presentation of the pros and cons of QFD.

Acknowledgement

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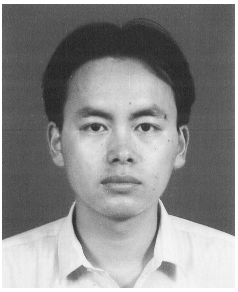

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