EXTENDING QUALITY FUNCTION DEPLOYMENT TO ENTERPRISE MOBILE SERVICES DESIGN AND DEVELOPMENT

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Abstract: *Quality Function Deployment (QFD) is a systematic approach used by teams to identify, communicate and prioritise customer requirements so that an organisation can improve products and services to exceed customer expectations. QFD is an effective approach to build customer's requirements into the products and services, to beat the competition, and to meet the customer's needs. There is reasonable consensus among researchers that QFD is a useful and beneficial approach to reduce the design time and design costs while improving the qualities of products and services. However, most reported instances of successful or unsuccessful QFD practices lie within a manufacturing setting. However, the QFD methodology can be altered to fit and benefit service industry for example mobile services. This paper proposes a framework based on QFD concepts and practices to improve the enterprise mobile services analysis, design and development. A case study was carried out on CyPhone services analysis, design and development. The objective of this research is to improve the quality of enterprise mobile services by maximally satisfying customer's needs on 3rd and future generation multimedia enterprise mobile services.*

Keywords: *QFD, mobile services, user needs, requirement, design, analysis, development*

1. INTRODUCTION AND BACKGROUND

Quality Function Deployment (QFD) was developed in Japan in the 1970s by Professors Yoji Akao and Shigeru Mizuno as a systematic approach to assure quality in manufacturing products. QFD is a design approach that was originally used by manufacturing firms to bring new products to the market sooner than the competition, with lower cost, and improved quality [8]. In its most basic form, QFD is a design approach that translates customer requirements into the appropriate technical requirements at each stage of the production process. Now companies in the computer software and hardware, chemical, pharmaceutical, consumer products, food and beverage, aerospace, defence, health care, education, utility, building, telecommunications and numerous other industries in Japan, North

America, Europe, and Australia have found QFD a flexible and efficient solution to meeting the increasing demands of a fast changing world [7].

A service is an economic activity that produces time, place, form, or psychological utility [1]. The main features of a service, which distinguishes it from a product, are intangibility, heterogeneity, and inseparability of production and consumption [5]. Mobile services quality can be defined as a measure of how well the mobile service delivered matches the customer expectation of the mobile services. Similar to manufacturing, a critical requirement to achieving high quality in the mobile services is the ability to deploy the customers' desires on multimedia mobile services. "Quality is achieved by systematic deployment of the voice of the customer throughout the organization and by the application of quality engineering to provide products that remain very close to ideal performance." [2]. Clearly, this philosophy is not limited to engineering products but also can be extended to service industry. Mobile services and many more can also be best developed by improving the service quality using QFD.

The existing mobile service analysis, design, and deployment methodologies are often assumed to allow developers to document and keep track of the customer or user requirements thus enabling development of services with which users are satisfied. Situations where users are dissatisfied with the mobile services are nevertheless not uncommon. This dissatisfaction is the result of the users' perceptions of quality not being met. It is important to realise that the traditional mobile services analysis, design and development methodologies do not explicitly document user quality attributes. They also make no provisions for ensuring that those quality characteristics are properly and systematically considered throughout the various stages of the development process. It is possible that some user requirements such as ease of use, attractiveness, and safety are not captured in up-front design stage. It may also be the case that some "unstated" or "unspoken" quality features are either not explicitly considered or they vanish in the stepwise refinement process.

Some QFD research has been successfully completed within Telecommunications. The international TechneGroup Inc. successfully used QFD to reduce the long mobile service connection and billing cycle time. However, mobile service designers and developers are lack of a complete and deep QFD understanding on mobile services. We therefore propose a framework for integrating QFD into the mobile services analysis, design and development process, in order to increase the likelihood of developing high-quality mobile services.

2. APPLYING QFD APPROACH ON ENTERPRISE MOBILE SERVICES DESIGN AND DEVELOPMENT

2.1 Understanding the User Needs

The QFD approach starts with understanding the user needs or requirements on mobile services. For example users may require that mobile services support real-time visual communication world widely. It is important to remember that there is no one monolithic voice of the user and user voices are diverse. These diverse voices must be considered, reconciled and balanced to develop a challenging mobile service. The general user needs of mobile services are categorised in Fig. 1.

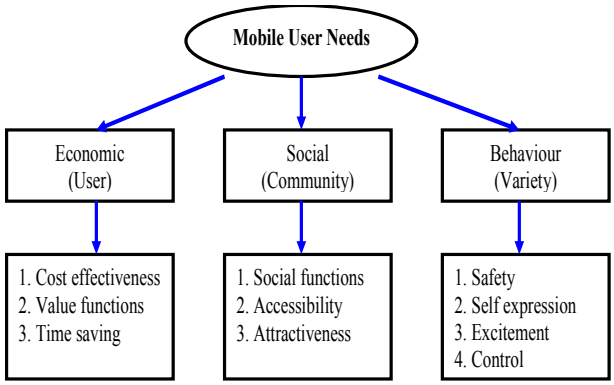

Fig. 1. Understanding user needs for mobile services

In Fig.1 the user needs of mobile services can be categorised as *economic*, *social* and *behaviour* needs. Each of them can be divided into more detailed user needs further. For example in *Behaviour* category the *Excitement* means that new capabilities of mobile service or unspoken needs that will cause user excitement. However, this is a general classification to indicate user needs in mobile services. It is expected to alter these needs a little bit to fit various mobile services (for example electronic banking and virtual telepresence) and different user groups

(for example students and business man) in implementation.

2.2 The Cubic QFD Model for Mobile Service Development

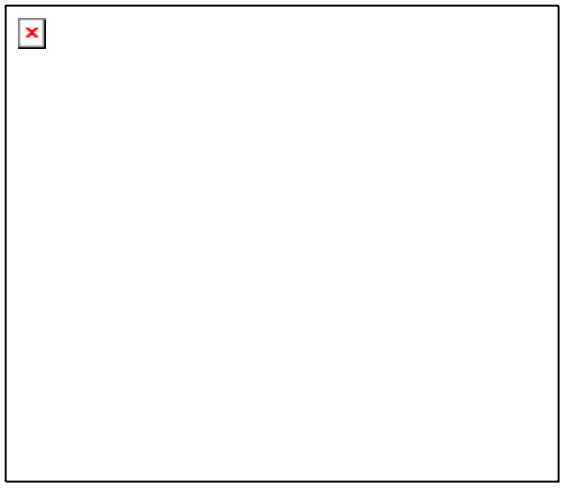

Fig. 2. A cubic QFD model for mobile service development

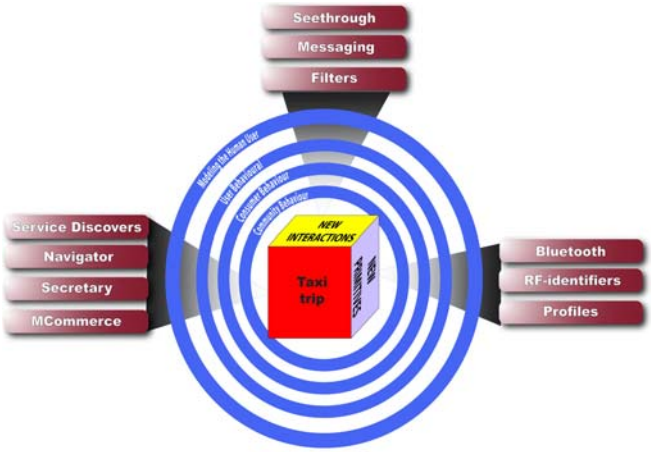

Fig. 3. CyPhone taxi trip cubic model

Fig. 2 describes a general cubic QFD model for mobile services development [6,9]. The three cubic sides, *mobile service*, *interaction elements* and *mobile components*, represent three research dimensions constructing the mobile services development process. The *mobile service* research is about deploying various multimedia mobile services and analyse different service scenarios. The *interaction elements* side is to study rich interaction between human and mobile terminals. The *mobile components* study is related to mobile service enabling platforms and components. In Fig. 3 an example is given which models the CyPhone taxi trip mobile service/scenario. The *service discovers*, *navigator*, *secretary* and *mobile commerce* represent four different mobile services that can be offered in taxi trip by using CyPhone. *Seethrough*, *messaging* and *filters* describe three essential interaction elements between human and the Cyphone. *Bluetooth*, *RF-identifiers* and *profiles* are three mobile components (enabling technology, standard or platform).

QFD approach can be applied on all of the three research dimensions. In Fig. 2 there are three QFD matrices matrix1, matrix 2 and matrix 3, representing QFD mobile service matrix, interaction element matrix and mobile component matrix respectively. General formats of the three QFD matrices are given in the following Table 1, 2 and 3.

Table 1: Matrix 1 the QFD matrix of mobile services

		Quality Characteristics / Demanded Quality	Mobile Services (Scenarios)			
			Mobile Transactions	Video Conference	Virtual Game	.....
User Needs	Economic	Cost Effectiveness				
		Value Functions				
		Time Saving				
	Social	Sicial Functions				
		Accessibility				
		Attractiveness				
	Behaviour	Safety				
		Self Expression				
		Excitement				
		Control				

In the QFD matrix of mobile services the user needs in these services are exploited. The different multimedia mobile services can include mobile transactions, video conference, virtual games, automatic driving, wireless control of home appliances etc., just to name a few. In the above matrix there are *demanded quality* at the left side of the matrix and *quality characteristics* at the top of the matrix. The *demanded quality* is derived from customers' needs on a specific mobile service. This is WHAT they expect from the mobile service. The *quality characteristics* represent the measurable and quantitative parameters to achieve the user needs. This is HOW to express the user needs in a technical parameter. Within a specific mobile service the parameters and importance of the *demanded quality* and *quality characteristics* may vary. For example in mobile transactions the safety issue is a significant demanded quality while in video conference no voice and image delay is highly demanded.

Table 2: Matrix 2 the QFD matrix of interaction elements

Quality Characteristics / Demanded Quality			Interaction Elements												
			Physical Contact	Avatar Appearance	Kinesics	Facial Expressions	Spatial Behaviour	Non-Verbal Audio	Occulesics	Environmental Details	Chronemics	Olfactics	Autonomous Actions	Language based Communication
User Needs	Economic	Cost Effectiveness												
		Value Functions												
		Time Saving												
	Social	Sicial Functions												
		Accessibility												
		Attractiveness												
	Behaviour	Safety												
		Self Expression												
		Excitement												
		Control												

The general mobile service interaction elements are listed in Table 2. These interaction elements are however based on a rich virtual game environment, which is a promising mobile service for entertainment. In a different mobile service the interaction elements may reasonably vary. The meaning of these interaction elements is explained below [4]:

Physical Contact: reflects the use of touch in communication situations.

- *Avatar Appearance*: defines the attributes of image and presentation of self.
- *Kinesics:* includes all bodily movement except touching, commonly referred to as body language.
- *Facial Expressions*: may be broken down into the sub-codes of eyebrow position, eye and mouth shape and nostril size.
- *Spatial Behaviour*: consists of proximity, orientation, territorial behaviour and movement in a physical setting.
- *Non-verbal Audio*: includes the use of the voice in communication, which is often referred to as *paralanguage*. The non-verbal aspects of speech contain prosodic and paradigmatic codes.
- *Occulesics*: are movements in facial area and eyes, e.g., gaze.
- *Environmental Details*: define the appearance of surroundings providing contextual cues.
- *Chronemics:* involves the use and perception of time.
- *Olfactics:* reflect to the non-verbal communicative effect of one's scents and odours.
- *Autonomous Actions:* includes a set of pre-programmable actions and reactive behaviour that resembles sub-conscious and intuitive acts in the physical world.
- *Language based Communication:* is the major channel for interpersonal information sharing in most of the current collaborative virtual environments (CVEs).

Table 3: Matrix 3 the QFD matrix of mobile components

Quality Characteristics / Demanded Quality			Mobile Components				
			PAN	Ubiquitous	Partner	Global	Cyber
User Needs	Economic	Cost Effectiveness					
		Value Functions					
		Time Saving					
	Social	Sicial Functions					
		Accessibility					
		Attractiveness					
	Behaviour	Safety					
		Self Expression					
		Excitement					
		Control					

The mobile components are about mobile service enabling platforms and components. Five level components are defined namely *PAN, ubiquitous, partner, global and cyber*. Different components are located at the five different levels and they must be designed and developed according to the user needs.

2.3 Building "The House of Quality"

Once the demanded qualities are gathered, they must be translated into quantitative and explicit quality characteristics. For which design targets will be set. The relationships between demanded quality items and quality characteristics are best managed in a two dimensional matrix (Fig. 4). This matrix is then be used to prioritise the demanded quality items based on user or customer importance, competitive position and company vision. Because this matrix can be seen to resemble a house in some cases it is called "House of Quality". This matrix is then used to prioritise the demanded quality items in order to transfer into quality priorities based on customer importance, competitive position, and company vision. Then the mobile service designers can use the results to locate the best solution among

all available options that will best satisfy the customers in their own minds. Once a general solution, such as a system-level mobile service solution is selected, and verified to meet the customer needs as originally stated, more detailed sub-system options can be analysed and selected. The output of one level of "House of Quality" analysis can become the input to the next, more detailed level, until the final items and components of the overall system are selected in as fine a detail as feasible.

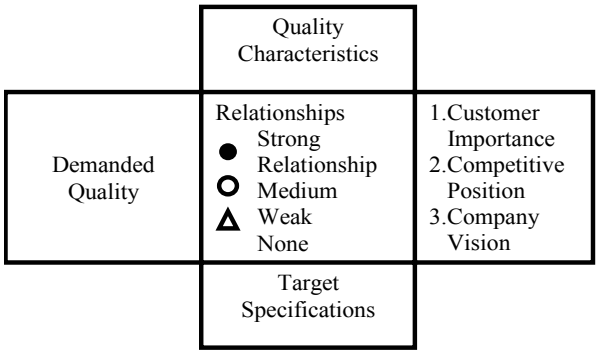

Fig. 4. The house of quality model

2.4 From QFD to Mobile Service Output

After the QFD matrices the best solution will be selected and it then comes with the design concepts to achieve the quality targets. The best design concept is chosen based on cost, reliability, safety etc. and critical parts are determined for process. With the aid of proper process tools or technologies it outputs with the desired mobile service quality. The procedure of applying QFD to mobile services can be briefly illustrated in the following Fig. 5.

Fig. 5. Procedure of applying QFD on mobile service design and development

3. QFD COST ANALYSIS OF MOBILE SERVICES

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 to 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 8000 of these "benefit points", but would cost $4m and 2 years of design work to deliver. Another far less important quality characteristic would only deliver 1500 "benefit points", but could be done for $500k and only 6 months to complete. The ratios (2.0 vs. 3.0) tell a far different story than the "benefit points" alone (8000 vs. 1500) and will help the service team to 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.

4. A CASE STUDY OF THE USE OF QFD IN CYPHONE MOBILE SERVICES

The CyPhone is a small sized combination of a digital stereo camera, a notepad computer and a cellular phone [6]. The CyPhone network is backboned by the picocellular technologies that allowing transmission of high bandwidth of data. The CyPhone framework can be used as a platform for some promising mobile services that can be classified as:

- Annotation services (guidance, electronic commerce)
- Telepresence services (tourism, education, nursery)
- Monitoring and maintenance (real-estate and property maintenance and alarm systems)

- Home services (child and senior citizen daycares)
- Entertainment services (group games, athletics, training)
- Personal services (pets, virtual family, cyber dating)

Table 4: "House of Quality" of a case study

Here we would like to give a simple example of how to build the QFD "House of Quality" matrix on the novel mobile telepresence analysis, design and development (Table 4).

WHATs vs. HOWs

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

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 telepresence 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	○	○	●			○		5		2	3	2	5	2.5	1.5	18.7	67.6
No transmission delay	△	●					△	4		3	2	3	4	1.3	1.2	6.4	49.4
Easy wireless access	●	○				△	○	3		4	3	2	4	1	1.2	3.6	40.9
Cost effectiveness		○		●	●		●	3		4	3	4	4	1	1.5	4.5	45
Terminal mobility	●					●	○	4		3	4	3	4	1.3	1.0	5.2	45.2
Service mobility	●	●		○		△	●	5		3	2	2	5	1.7	1.5	12.8	61
Absolute weight	1576	1454	608	588	405	652	1262										
Quality characteristic weight	24	22.2	9.3	9	6.2	10	19.3										
Competitive benchmark																	
Our current service	500	64	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	256	1024	70	5	50	500										
Unit	km	Kb/s	pxl	Tcost. K$	Ncost $/Unit	Weight Kg	Watt										

In the above Table 4 the demanded quality of telepresence are gathered and expressed as *high quality images*, *no transmission delay*, easy *wireless access, cost effectiveness, terminal mobility and service mobility* while the telepresence quality characteristics are defined as *Network coverage*, *data transmission speed*, *display resolution*, *terminal costs, network access cost per time unit, terminal size and weight, and power consumption.* A common concern in telepresence is to obtain virtual clear images. The demanded quality is then expressed as *high quality images* in the first row on the left side of the matrix. The seven quality characteristics at the top of the matrix must be considered in order to get high quality images.

From the right side of the matrix we can see that *high quality images* received a customer importance of 5 on a scale from one to five, indicating strong importance to the telepresence users. In the company's current telepresence service the *high quality images* is only ranked 2 on a scale from one to five. This is obviously not competitive. The company X and Y are ranked 3 and 2 respectively on *high 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. Sales points reflect the vision of the company 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 x improvement ratio x sales points, for *high quality images* we get 5 x 2.5 x 1.5 = 18.75. At last the demanded quality weight is calculated by normalizing the absolute weights to a percentage. 18.75 / (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 company vision.

After obtaining the demanded quality weights we now can convert them to 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 its strength: • = 9, o = 3 and Δ = 1. 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 x 3 = 202.8, 49.4 x 9 = 444.6, 40.9 x 3 = 122.7, 45 x 3 = 135, 61 x 9 = 549. Sum, 202.8 + 444.6 + 122.7 + 135 + 549 = 1454. Normalizing it to a percentage we get a quality characteristic weight of 22.2 %. This means based on customer importance, competitive position and company vision, 22.2 % of the telepresence design focus should be put on *data transmission speed.* For example a target specification 256 kb/s is selected for the *data transmission speed* instead of our current 64 kb/s. The designer can then develop appropriate mobile technology and mobile terminal to achieve this target. The QFD approach then should be carried forward into designing and developing mobile technologies and terminals because QFD can be applied in the whole service and sub-component design and development process. The new mobile service will best meet the customer needs and beat competitors in marketplace.

5. CONCLUSIONS AND FUTURE WORK

In this paper we have examined the possibility to use QFD on mobile services analysis, design and development. A case study was carried out on design and development of mobile telepresence service. The critical focus areas are successfully identified. 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 trying to apply QFD to several mobile service projects. 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.

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