Communication Behavior Modification

Application for Promoting Wi-Fi Network Usage by Visualizing Usage History

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***Abstract*— With the rapid increase in the use of high performance Information Communication Technologies (ICT) devices, the control of network quality for congestion avoidance has become increasingly important in network service design. Service quality should be discussed from a user experience perspective and the same holds for network quality. However, it is less common to integrate a human-centered design viewpoint when improving network performance. In this paper, we discuss a concept that allows users to choose an appropriate network by visualizing network usage history. The main contribution of this paper is to show quantitatively the effect of this concept by developing a prototype application for smart phones. The application visualizes network usage history through entertaining content. Users enjoyed it and consequently were able to improve network performance by modifying their communication behavior. Field studies show that 47% of participants enjoyed using the application and 28% of participants increased their use of Wi-Fi networks.**

Keywords-service quality; user experience; human-centered design; human-network interaction; field study.

I. INTRODUCTION

The rapid change in mobile usage has brought about greater diversity in lifestyles [1]. People more frequently use high-performance Information Communication Technologies (ICT) devices, such as smart phones and tablet computers, and traffic volume is showing a sharp increase, which is a primary cause of traffic congestion in Internet Protocol (IP) networks and degradation of network quality. To achieve better service quality, controlling network quality becomes increasingly important in ICT service design.

One way this congestion problem is being tackled is through an engineering strategy, i.e., strengthening network infrastructure in terms of both quantity and quality. It makes a direct contribution to solving the congestion problem. However, this strategy is costly because of the vast size and complexity of implementing a cutting-edge network; consequently solving this problem weighs heavily on telecommunications operators. On the other hand, users sometimes develop a cognitive strategy to alleviate their dissatisfaction. A typical strategy is called multitasking whereby users move their attention away from the waiting process and try to reduce their sense of dissatisfaction.

In order to understand users' cognitive strategies, it is necessary to analyze network services from a user perspective. One approach is called Quality of Experience (QoE). In ITU-T Appendix I to P.10/G.100 [2], QoE is defined as "The overall acceptability of an application or service, as perceived subjectively by the end-user." Several studies have analyzed network services taking this definition into consideration. For example, Niida et al. [3] have reported on user tolerance for waiting time in mobile communications. While this approach is very useful for providing quality criteria for network planning, a new perspective is required to deeply understand cognitive strategies. Users' behavior when using devices connected to information networks (we call it communication behavior) is a contiguous judgment process embracing not only waiting, but also migration, cancellation, and so on. Users are influenced by past experiences and change their behavior accordingly. They are not static evaluators. To evaluate such dynamic communication behavior in order to understand cognitive strategy, the authors introduce the concept of "network usability".

Usability of ICT devices has been studied for a long time. In the earlier studies, it was mainly discussed in terms of time efficiency performance [4]. Subsequently, Norman defined a cognitive artifact as "an artificial device designed to maintain, display, or operate upon information in order to serve a representational function" [5], and the importance of human cognitive processes in interactions between users and artifacts was pointed out. The authors define network usability as the usability in Human-Network Interaction (HNI). Figure 1 shows a conceptual diagram of HNI which regards the network as a cognitive artifact. The network maintains and displays information which indicates network status. It is also controlled by users by selecting a preferred behavior. Users modify their communication behavior depending on the situation. If the network has a high degree of usability, this means that people can control network services with a low cognitive burden to accomplish their goal or solve their problem.

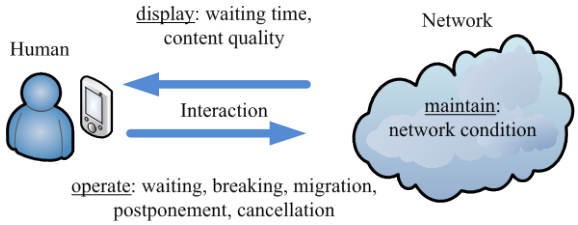

Figure 1. Conceptual diagram of human-network interaction.

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This paper proposes a concept that allows users to choose an appropriate time and place for using a wireless network based on their past experience. By learning from past experience, users are encouraged to use a high quality network. From the perspective of network usability, the authors designed an application that visualizes the network usage history as a form of entertainment and which allows users to understand past experiences easily. The main contribution of this paper is to demonstrate quantitatively the effect of the application by two different field studies conducted sequentially.

This paper is organized as follows. In Section 2, related work is summarized. In Section 3, the proposed concept is presented. In Sections 4, the evaluation process based on the results of the field experiment using a prototype is presented. Finally, Section 5 concludes the discussion.

II. RELATED WORK

There are three related areas to our research; the cognitive processes that are involved when using a network service, usability and communication behavior modification.

Subjective quality assessment is one of the approaches utilized to analyze cognitive process when using a network service. It has been studied for a long time in the area of international standardization activities. For an interactive service such as web browsing and downloading, ITU-T Recommendation G.1030 [6] defines the procedure for subjective quality assessment of website access on PCs. Some research has also been conducted on QoE for web access services on personal computers [7] and downloading services [8]. There has also been some research on the cognitive processes related to waiting. Some studies have aimed at reducing the dissatisfaction associated with waiting by reporting the situation [9][10]. Antonides et al. [11] and Munichio and Rafaeli [12] analyzed the effect of various time-fillers in telephone queues (fillers include music, apologies, and information about location in the queues) based on the results of field experiments. These studies succeeded in explaining the change in users' impression but not the change in user's behavior.

Many studies have evaluated the usability of a mobile computing environment [13]. With regard to usability during multitasking, Nagata [14] has estimated the effect of interruption on web task performance, and Parlangeli et al. [15] evaluated the effects of a teaching system for distance learning in a multitasking context. These studies revealed the negative effect of multitasking on task performance. On the other hand, Uemura et al. [16] reported the positive effect of multitasking in reducing the dissatisfaction associated with waiting time. These studies did not address the question of network usability.

There are few studies on communication behavior modification. Motoyoshi et al. [17] and Murase et al. [18] proposed a navigation system for behavior modification. They introduced a method called Comfort Route Navigation (CRN) which provides users with the optimal route for maximizing throughput in a heterogeneous network. This method can modify users' behavior by anticipated throughput but does not take past experience into consideration. Another approach is utilizing pricing mechanisms to avoid network congestion [19]. This can be effective for modification of communication behavior in usage based pricing. However, with the popularization of flat rate pricing, we need different concept.

III. PROPOSED CONCEPT

We propose a concept that allows users to choose an appropriate network by helping them to understand network usage history. Recent mobile terminals support various wireless interfaces such as 3G, LTE, Wi-Fi and WiMAX. While people can use the terminal unconstrained by time and place, network performance depends on the time and place of use. For example, users can utilize a better quality network at home if they install Wi-Fi. In this case, users can improve average throughput by preferentially using Wi-Fi at home, meaning it is better if they download or upload large files at home. However, many users are not conscious of the correlation between throughput and time and/or place. Accordingly, they try to use a network whenever they want to and become frustrated if the network condition is poor.

The authors have designed an application in which a city map expands based on network usage history data. It is not like gaming but more like entertainment. This will belong to concept of "gamification" [20]. Users can easily understand their usage history as the city map expands. Users cannot operate directly any items in this application. However, users can influence the application by changing their behavior in daily life. They can maintain the motivation to check network usage history while enjoying the entertainment application. In this paper, we will discuss a relation between users' involvement level to this application and feedback level from this application. The design of the application is described in specific detail in the next section.

IV. IMPLEMENTAION AND FIELD TRIAL

A. 1st Implementation

Figure 2 shows screen shots of the application used in the first implementation. This is an entertainment application in which parts of city maps are added based on the cumulative amount of use of a network. In the initial state, the sea areas are displayed on all screens as shown in Fig. 2(a). The areas comprising the city will be arranged on a screen if the cumulative amount of use of a Wi-Fi network increases as shown in Fig. 2(b). There are about a hundred types of city parts and the algorithm of this application chooses city parts and adds them on the map. The more user uses Wi-Fi over the smart phone, the more city parts arrange on the map. The city parts are selected based on the types of applications which user has used over the smart phone. Then the ambience of the city differs depending on users' behavior. It is expected that a user will feel motivated to connect with Wi-Fi spontaneously by promoting the growth of the city. Users enjoy the growth of the city and view it as entertainment and consequently improve the network performance they experience.

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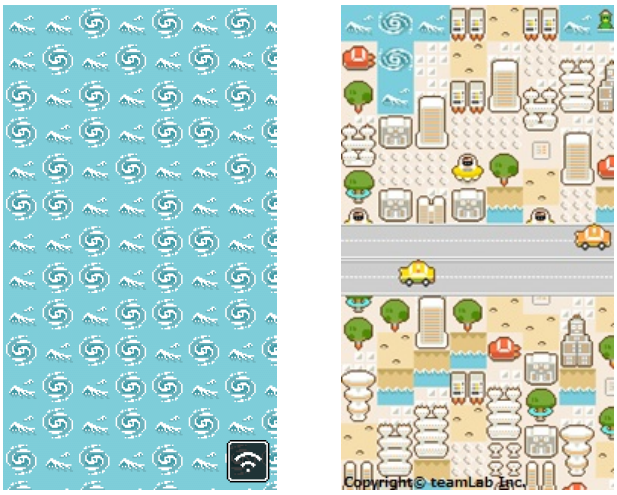

(a) Initial state (b) Steady state

Figure 2. Screen shot of 1st implementation application

We conducted a field study using this application. There were 31 participants (19 males, 12 females) in this experiment. The participants were all Japanese nationals and registered with an online survey company. They were aged from 20 to 34 years and used a smart phone in daily life. They were asked to use the application for one week and answer the questionnaire below after that.

- Q1: Do you think the application helped you to understand the Wi-Fi usage history? (a five-point scale: very much = 5 to not at all= 1)
- Q2: Did you increase the frequency of connecting to a Wi-Fi network at home? (a three-point scale: increase = 3, same as before = 2, decrease = 1)
- Q3: Did you increase the frequency of connecting to a Wi-Fi network outside the home? (same as Q2)
- Q4: Do you want to continue to use the application? (a five-point scale: very much = 5 to not at all= 1)

Table I shows the percentage responses to each question. 19.4% of participants had a positive response to Q1. 71.0% of participants increase the frequency of connecting to a Wi-Fi network outside the home.

TABLE I. RESPONSES TO 1ST TRIAL (%)

Question No.	Answer				
	5	*4*	*3*	*2*	*1*
Q1 (understand NW usage history)	6.5%	12.9%	38.7%	29.0%	12.9%
Q2 (increase Wi-Fi usage at home)	-	-	9.7%	90.3%	0.0%
Q3 (increase Wi-Fi usage outside)	-	-	71.0%	29.0%	0.0%
Q4 (continuation intention)	0.0%	22.6%	12.9%	38.7%	25.8%

Table II shows the correlation of each answer. Q1 showed a weak correlation with Q3 and Q4. This indicates an increasing number of participants thought the application helped them to understand Wi-Fi usage history the more they increased their use of Wi-Fi and these participants also felt positive about continuing to use the application. However, only 22.6% of participants felt positive about continuing to use the application.

TABLE II. CORRELATION BETWEEN ANSWERS IN 1ST TRIAL

Question No.	Question No.			
	Q1	*Q2*	*Q3*	*Q4*
Q1 (understand NW usage history)	1	.09	.36*	.36*
Q2 (increase Wi-Fi usage at home)	-	1	.21	.20
Q3 (increase Wi-Fi usage outside)	-	-	1	.26
Q4 (continuation intention)	-	-	-	1

* 5% level significance

From these results, it has confirmed that communication behavior was modified by visualizing network usage history. However, the impact of the application did not reach the anticipated level. We redesigned the application based on the comments participants freely made about the questionnaire.

B. 2nd Implementation

Figure 3 shows a screen shot of the revised application used in the 2nd implementation. We added two new features. The first feature comprises two indicators which show cumulative traffic volume passing through a wireless network. These are the tree type indicator located in the center of the city map and the bar type indicator located on top of screen. Participants can check how much traffic is being transmitted over a Wi-Fi network more easily than with the 1st implementation. The second feature is cooperation with SNS (Social Network Service). It enhanced the entertainment property by arranging followees' statements on the city map and expect to increase the frequency to check the application.

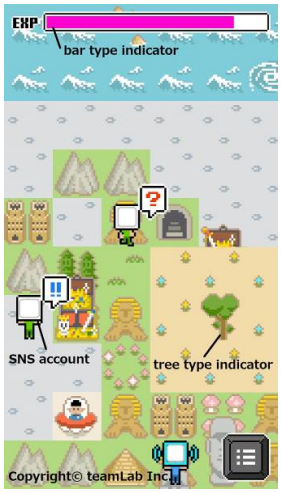

Figure 3. Screen shot of 2nd implementation application

There were 32 participants (18 males, 14 females) in the 2nd experiment. The participants were all inhabitants of Japan and registered with an online survey company. They were aged from 20 to 33 and used a smart phone in daily life.

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They were asked to use this application for one week and answer the questionnaire after that. In the 2nd field trial, we added the question below.

- Q5: Did you enjoy using the application? (a five-point scale: very much = 5 to not at all = 1)

Table III shows the percentage response to this question. 31.2% of participants had a positive response to Q1. 21.9% of participants increased their frequency of connecting to a Wi-Fi network at home or outside. 28% of participants increased their Wi-Fi usage at home and/or outside.

TABLE III. RESPONSES TO 2ND TRIAL (%)

Question No.	Answer				
	5	*4*	*3*	*2*	*1*
Q1 (understand NW usage history)	3.1%	28.1%	15.6%	21.9%	31.3%
Q2 (increase Wi-Fi usage at home)	-	-	21.9%	75.0%	3.1%
Q3 (increase Wi-Fi usage outside)	-	-	21.9%	78.1%	0.0%
Q4 (continuation intention)	6.3%	25.0%	15.6%	21.9%	31.3%
Q5 (enjoy using application)	15.6%	31.3%	12.5%	15.6%	25.0%

Table IV shows the correlation of each answer. Q1 showed a medium correlation with Q4 and Q5. There were more positive responses to the 2nd implementation compared to the 1st implementation. From these results, it can be seen that the new features improved the performance of the application.

TABLE IV. CORRELATION BETWEEN ANSWERS IN 2ND TRIAL

Question No.	Question No.				
	Q1	*Q2*	*Q3*	*Q4*	*Q5*
Q1 (understand NW usage history)	1	.05	-.03	.62**	.55**
Q2 (increase Wi-Fi usage at home)	-	1	.60**	.45*	.20
Q3 (increase Wi-Fi usage outside)	-	-	1	.13	.01
Q4 (continuation intention)	-	-	-	1	.74**
Q5 (enjoy using application)	-	-	-	-	1

** 1% level significance

This indicates that an increasing number of participants thought the application helped them to understand usage history of Wi-Fi the more they felt positive about the application and continued to use it. However, the correlations between Q3 and other questions, which were apparent in the 1st field test, disappeared.

V. CONCLUSION AND FUTURE WORK

We proposed a concept that allows users to choose an appropriate time and place for using a wireless network based on their past experience. We evaluated this concept by developing an application which visualizes the network usage history. The results from two field studies show that our concept has the potential to modify communication behavior. However, the impact of the application did not reach our expected level. We will redesign the application interaction again and confirm if users offload traffic to Wi-Fi by using this application.

RESSFERENCES

[1] M. Ito, D. Okabe, and M. Matsuda (Eds.) "Personal, Portable, Pedestrian: Mobile Phones in Japanese Life," MIT Press, 2005.

[2] ITU-T Appendix I to P.10/G.100, "Definition of QoE," 2007.

[3] S. Niida, S. Uemura, and H. Nakamura, "Mobile services - User tolerance for waiting time-," IEEE Vehicular Technology Magazine, vol. 5, no. 3, pp. 61-67, Sept. 2010.

[4] S. K. Card, T. P. Moran, and A. Newell, The Psychology of Human-Computer Interaction, Erlhaum, Hillsdale, 1983.

[5] D. A. Norman, "Cognitive Engineering," In D. Norman and S. Draper (Eds.) User Centered System Design: New Perspective on Human Computer Interaction, Hillsdale, NJ: Lawrence Erlbaum Associates Inc., pp. 31-62, 1986

[6] ITU-T Recommendation G.1030, "Estimating end-to-end performance in IP networks for data applications," 2005.

[7] E. Ibarrola, F. Liberal, I. Taboada, and R. Ortega, "Web QoE evaluation in multi-agent networks: Validation of ITU-T G.1030," Proc. ICAS'09, pp. 289-294, Apr. 2009.

[8] K. Nomura, K. Yamori, E. Takahashi, T. Miyoshi, and Y. Tanaka, "Waiting time versus utility to download images," Proc. APSITT 2001, pp. 128-132, Nov. 2001.

[9] C. Harrison, Z. Yeo, and S.E. Hudson, "Faster Progress Bars: Manipulating Perceived Duration with Visual Augmentations," Proc. CHI 2010, pp. 1545-1548, Apr. 2010.

[10] S. Niida, S. Uemura, and E. T. Harada, "Design Requirements for Improving QoE of Web Service Using Time-Fillers," IEICE Trans. Commun., E96-B, pp. 2069-2075, Aug. 2013.

[11] G. Antonides, P.C. Verhoef, and M. van Aalst, "Consumer perception and evaluation of waiting time: A field experiment," Journal of Consumer Psychology, no. 12, pp. 193-202, 2002.

[12] N. Munichor and A. Rafaeli. "Numbers or apologies? Customer reactions to telephone waiting time fillers," Journal of Applied Psychology, no. 92, pp. 511-518, Mar. 2007.

[13] C. K. Constantinos and D. J. Kim, "A Meta-Analytical Review of Empirical Mobile Usability Studies," Journal of Usability Studies Vol. 6, no. 3, pp. 117-171, May 2011.

[14] S. F. Nagata, "Multitasking and interruptions during mobile web tasks," Proc. the Human Factors and Ergonomics Society Annual Meeting, pp. 1341-1345 , 2003.

[15] O. Parlangeli, G. Mengoni, and S. Guidi, "The effect of system usability and multitasking activities in distance learning," Proc. CHItaly, Sep. 2011.

[16] S. Uemura, S. Niida, and H. Nakamura, "Service control system based on behavioral characteristics of user multitasking," Proc. CENTRIC 2011, pp. 22-27, Oct. 2011.

[17] G. Motoyoshi, Y. Sudo, T. Murase, and T. Masuzawa, "Advantages of Optimal Longcut Route for Wireless Mobile Users," Proc. IEEE ICC 2011, pp. 1-6, Jun. 2011.

[18] T. Murase, G. Motoyoshi, K. Sonoda, and J. Katto, "Quality of service of mobile users for longcut routes with congested access points," Proc. ACM ICUIMC '13, no. 40, Jan. 2013.

[19] J. K. MacKie-Mason and H. R. Varian, "Pricing Congestible Network Resources," IEEE J. SAC, pp. 1141-1149, Sept. 1995.

[20] S. Deterding, D. Dixon, R. Khaled, and L. Nacke, "From game design elements to gamefulness: defining gamification," Proc. MindTrek '11, pp. 9-15, Sept. 2011.

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