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User Preference for Fixed vs. Mobile Internet regarding Quality of Service: Its Implications on Mobile Network Neutrality

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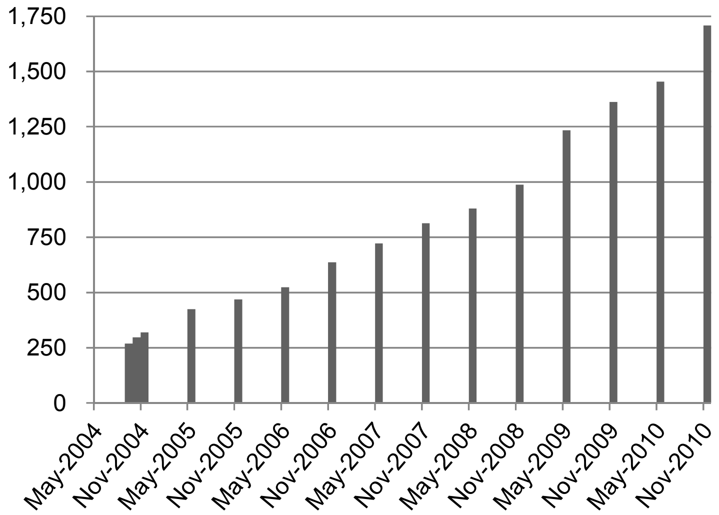
Abstract

The rapid development of information and communication technology has facilitated Internet use considerably, particularly with regard to the speed of packet transfer at access segments. With the boom in bit-intensive and live-streaming content in the broadband Internet ecosystem, the phenomenon of increasing and persisting congestion on the Internet is no longer a mere engineering possibility but a grave and imminent reality. To deal with this problem, "network neutrality" has become the focus of discussion among operators, academics, and telecom regulators in recent years. Over the past several months, one of the most contentious issues in the US discussion of network neutrality has been whether both mobile and fixed Internet access should comply with similar network neutrality standards. Unfortunately, thus far, policy has been developed and academic debates have taken place without an understanding of the extent to which fixed and mobile Internet services are, from the user's perspective, close substitutes. Therefore, it is impossible to determine whether it is beneficial to treat these services similarly. Using a Web-based questionnaire, this paper shows empirically that users' communication quality preferences for fixed broadband differ significantly from their preferences for its mobile counterpart, suggesting that different treatments should be proposed for each broadband medium in order to attain optimal resource allocation.

1. Introduction

The rapid development of information and communication technology has facilitated Internet use considerably, particularly with regard to the speed of packet transfer at access segments. In addition, with the expansion of broadband Internet, consumers have benefited from an ever-increasing number of applications that enable various activities, leading to the improvement of social welfare. However, with the boom in bit-intensive and live-streaming content, the phenomenon of increasing and persisting congestion on the Internet is no longer a mere engineering possibility but a grave and imminent reality that may harm the user experience. For example, congestion on the Internet will force subscribers to wait longer to download content from distant servers and will make quality of service (QoS)-sensitive applications, such as VoIP and online games, unusable. Rapid migration to the ultra-high-speed broadband environment—or next-generation access and 4G mobile—will motivate users to try out "richer" content and applications, thereby aggravating the congestion problem. Cisco (2010, p. 2) forecasted that "in 2014, the Internet will be four times larger than it was in 2009." Japan is no exception; according to the Ministry of Internal Affairs and Communications (MIC), as of November 2010, the total volume of download packets by Japanese broadband users had reached 1.71 terabits per second (Tbps), which amounts to 125.4% of the previous year's downloads (MIC, 2011) (Figure 1). Fortunately, owing to massive investments in the Internet ecosystem, Japan has not yet experienced a traffic blackout. However, as early as 2007, the MIC reported that 90% of downloading capacity and 80% of uploading capacity were utilized during peak hours (MIC, 2007).



Source: Created based on MIC data (2011)

Figure 1 Daily average download speeds of broadband users in Japan (in Gbps)

Since "one of the distinguishing features of TCP/IP is that it handles packets anonymously on a 'first come, first served' basis without regard to the application with which they are associated" (Spluber & Yoo, 2009, p.383), this congestion will clog the system during peak times and damage the Internet experience of all users. If some Internet service providers (ISPs) try to control the traffic flow and optimize the network, there may be an anti-competitive impact, particularly as these ISPs control bottleneck facilities and have strong market power. To address this situation, "network neutrality," a term coined by Wu (2003) to connote the equal and fair treatment of Internet packets by ISPs, has become the focus of discussion among operators, academics, and telecom regulators in recent years.

Through long and acrimonious discussions among stakeholders, many issues have emerged as key components of the network neutrality discussion. Over the past several months, one of the most contentious in the US has been whether mobile and fixed Internet access should comply with similar network neutrality standards. Major ISPs that are vertically integrated with mobile network operators have opposed strong mobile regulations. They argue that since mobile broadband must deal with several difficulties that its fixed counterpart does not, such as the size and technological features of allocated bandwidth, collective consumption of last mile connections, mobility of terminal equipment, and interference with neighboring bands, it requires additional discretion in network operations that fixed counterparts do not need. By contrast, considering the increasing pervasiveness of mobile broadband Internet, the other side of the argument insists that strict rules are needed to ensure a subscriber's Internet experience.

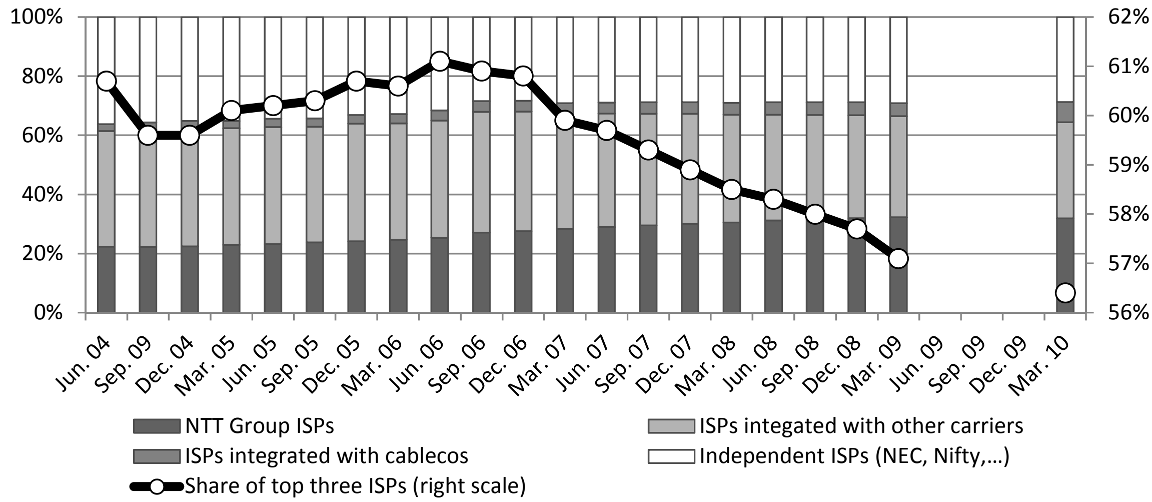
It seems that neither side has supported its arguments with empirical data regarding consumers' perspectives on their Internet experience; thus, both have failed to prove their superiority from the viewpoint of overall efficiency, which covers not only the provider side but also the consumer side. For example, in Japan, the MIC introduced a "co-regulation"-like framework to deal with network neutrality and requested the private sector to create a packet-shaping guideline to give equal treatment to fixed and mobile broadband. On the other hand, on December 21, 2010, in a 3-2 vote, the Federal Communications Commission (FCC) passed a set of rules to treat mobile ISPs differently from their fixed counterparts (FCC, 2010). However, both agencies failed to incorporate mobile broadband users' perspectives in their rule-making processes. The Japanese guideline was based solely on discussions between ISPs and telecom carriers. Even the well-resourced FCC admitted that they "do not know, for example, how end users will value the trade-offs between the benefits of wireless service (e.g., mobility) and the benefits of fixed wireline service (e.g., higher download and upload speeds)" (FCC, 2010, para. 33).

Users' perspectives on mobile QoS and fixed QoS are the author's primary research interest. The rest of this paper is organized as follows. Section 2 explains the framework of the net neutrality problem in Japan and the significance of this research for Japan's settings. Section 3 provides the empirical findings derived from the conducted Web-based questionnaire. Section 4 discusses the implications of the findings for network neutrality regulations and concludes the paper.

2. Network Neutrality and Japan's Approach

From the viewpoint of economic theory, as discussed in Jitsuzumi (2010), various issues or symptoms in the network neutrality discussion arise in principle from supply constraints in the network infrastructure of ISPs. These can be classified into two groups: one relates to packet congestion over the Internet infrastructure due to packet "exaflood," and the other relates to the possibility of anti-competitive behaviors by a dominant ISP that controls network bottlenecks. Concerning the first group, based on theoretical developments thus far dealing with car traffic congestion, economists have suggested demand control as a short-term solution and capacity expansion as a long-term solution. However, since the location and intensity of packet congestion is more ephemeral and unpredictable, special modifications are necessary, at least in the short term. One such modification for short-term congestion management is a real-time auction of bottleneck capacity: the "smart market" proposed by MacKie-Mason and Varian (1994). For the long term, ISPs must expand network capacity to accommodate the imminent traffic overflows. Considering the increasing pace of technological development and demand expansion, such a capacity build-up will be a never-ending process. Thus, ISPs must find sustainable business models that support continuous investment. Indeed, some have tried to depart from the traditional "all-you-can-eat" monthly flat rate to a metered tariff or a tariff with a monthly usage cap. To address the second group of issues, anti-competitive ISP behaviors, we must prevent dominant ISPs from overusing their market powers. The history of telecom regulation suggests that opening the market to introduce competition or mimicking competitive pressure via incentive regulations would be more effective than the administrative micro-management of ISP behavior, which has included rate and entry regulations.

Almost all developed nations, in which people can enjoy state-of-the-art Internet experiences over sophisticated infrastructures, are currently facing the above-mentioned challenges to varying degrees. In Japan, for example, the MIC does not have to worry about anti-competitive behaviors by dominant ISPs, because the MIC has long used significant market power (SMP) to regulate the market-dominating NTT Group (NTT East and NTT West), and has successfully maintained the competitiveness of the broadband ISP market. According to the MIC (2010c), in the large ISP market[1], the top three ISPs (NEC BIGLOBE, NTT Communications, and Softbank BB) accounted for 56.4% of the market in 2010; this percentage has been gradually decreasing (Figure 2). Moreover, there is good reason to expect that competitiveness in the ISP market will remain in the future. Recently, in response to an increase in the NTT's market share in the FTTH market, the MIC expanded the scope of its SMP regulation to the newly constructed NTT's next generation network (NGN), showing its continuing determination to check NTT's power in the Internet ecosystem.



Source: Created based on MIC data (2008, 2009, 2010)

Figure 2 Shares in the Japanese broadband ISP market

Because it is unlikely that the second group of issues will become a major discussion topic in Japan for some time, the MIC has been able to focus its efforts on the first group, that is, the optimization of traffic management, which includes packet shaping. On September 19, 2007, after a ten-month discussion, the MIC's Working Group on Network Neutrality issued a final report (MIC, 2007) that suggested a co-regulatory approach where the MIC would provide legal oversight to the private sector's collaborative efforts. In response, ISPs and network operators organized a committee in September 2007, and in May 2008, they released a guideline that set voluntary standards for how packets would be shaped and how relevant information would be disclosed to subscribers (JAIPA et al., 2008; JAIPA et al., 2010).

However, the proposed co-regulation has two critical drawbacks: the lack of an enforcement mechanism and insufficient stakeholder participation. It is widely agreed that in order to give a co-regulatory framework proper authority, the active participation of all related stakeholders is essential. For example, Werback (2009) stressed the importance of open and fair participation in the standards development process. Moreover, end users' participation is important to establish an economically efficient standard for co-regulating packet shaping, because packet priority must be determined not only from a technological viewpoint but also from a socioeconomic perspective. During peak hours or in the case of natural disaster, VoIP packets used by first responders should be given the highest priority; however, these can be delayed by packets used by telemarketers; however, both of these IP packets are technologically and operationally

[1] Large ISPs are ISPs with more than 50,000 subscriber lines. There are 51 such ISPs with a total of 34.7 million subscriber lines as of March 2010.

identical. It was widely reported that after the Great Tohoku Earthquake in Japan in March 2011, the social networking service Twitter was used extensively to reorganize communications among sufferers and support groups. As long as it is text-based, such a grass-roots network can perform well without any need for congestion management. However, if it becomes richer in bandwidth usage, some kind of a prioritization mechanism that accurately reflects the level of the end users' urgency becomes necessary.

In Japan, as of the end of 2009, 80.1 million people (or 85.1% of Internet users) were using mobile terminals to connect to the Internet,[2] which suggests the need for congestion management for mobile broadband as well. It is widely agreed that one of the important aspects of "network neutrality" is providing every user with fair QoS, that is, guaranteeing the same level of user experience regardless of usage style. However, if users' attitudes toward mobile QoS are significantly different from their attitudes toward fixed QoS, introducing a sweeping QoS rule that covers both fixed and mobile broadband will not be economically optimal.

3. Empirical Findings on Mobile Broadband Use in Japan

In order to identify customers' preferences for their mobile broadband experience, particularly concerning mobile broadband service quality (mobile QoS) and differences in preference between mobile and fixed broadband, the author conducted a Web-based questionnaire survey in January 2011.

The survey period was from January 24 to 27, 2011; 768 valid responses were collected from 8,992 contracted monitors of Rakuten Research, Inc. The average age of the respondents was 44.5 years and annual household income was 5.947 million yen. At the time of the survey, respondents had, on average, 129.5 months (10.8 years) of Internet experience, spent 22.1 hours per week on the Internet, and paid 4,668.7 yen per month for Internet access. Among them, 472 respondents (61.5%) were FTTH users, 176 (22.9%) were ADSL users, and 100 (13.0%) were cable users. The share of FTTH users was 5.3 percentage points higher than the national average as of September 2010[3].

As for the mobile broadband, 22.1% of the respondents (219 out of 768) had used it before and 19.0% (146 out of 768) had used it within the last 12 months. All or some Internet fees were paid by 35.6% of the respondents (78 out of 219). Most of the experienced users had their fees paid by their employers or schools, or they used only free services such as public hotspots (Table 1).

Table 1 Use of mobile broadband

Frequency of use / Who is paying	Daily	Within the previous year	Not within the previous year	Never	Total
Respondents themselves	17 (34.7%)	39 (40.2%)	14 (19.2%)		70 (9.1%)
Respondents + Employer or School	3 (6.1%)	3 (3.1%)	2 (2.7%)		8 (1.0%)
Employer or School	2 (4.1%)	7 (7.2%)	6 (8.2%)		15 (2.0%)
No one (Free service only)	20 (40.8%)	36 (37.1%)	25 (34.2%)		81 (10.5%)
Do not know	7 (14.3%)	12 (12.4%)	26 (35.6%)		45 (5.9%)
N/A				549 (100%)	549 (71.5%)
Total	49 (100%)	97 (100%)	73 (100%)	549 (100%)	768 (100.0%)

[2] This figure includes 64.9 million users who use mobile terminals and personal computers to connect to the Internet. Those who use only mobile terminals number 8.9 million.

[3] www.soumu.go.jp/johotsusintokei/field/data/gt010103.xls

Here we assume that respondents who used mobile broadband daily or within the previous year (hereafter called "active mobile users") maintain or easily re-sign subscription contracts with mobile Internet providers. Because all respondents had a fixed broadband connection at home, these active mobile users had broadband coverage both inside and outside the home. All of their broadband contracts were offered under the condition of the "best-effort" QoS, meaning they possibly experienced far less than the advertised speed. Indeed, according to the Ookla speed test[4], sample users were actually experiencing 27.4% of advertised download speed and 13.4% of advertised upload speed on average. Nearly all active mobile users (95.2%) said that actual speed is important for their Internet experience, and only 15.8% were satisfied with their current actual speeds measured by Speedtest. The following two questions were asked of active mobile users to identify their attitudes toward QoS improvement.

Q1: Would you agree to spend an additional "X"[5] yen per month if your ISP could guarantee a certain bandwidth that you would find appropriate as best-effort quality at your current subscription contract in your current fixed environment?

Q2: Would you agree to expend an additional "Y"[6] yen per month if your ISP could guarantee as much bandwidth along your commuting route as what you are currently enjoying at home under best-effort QoS?

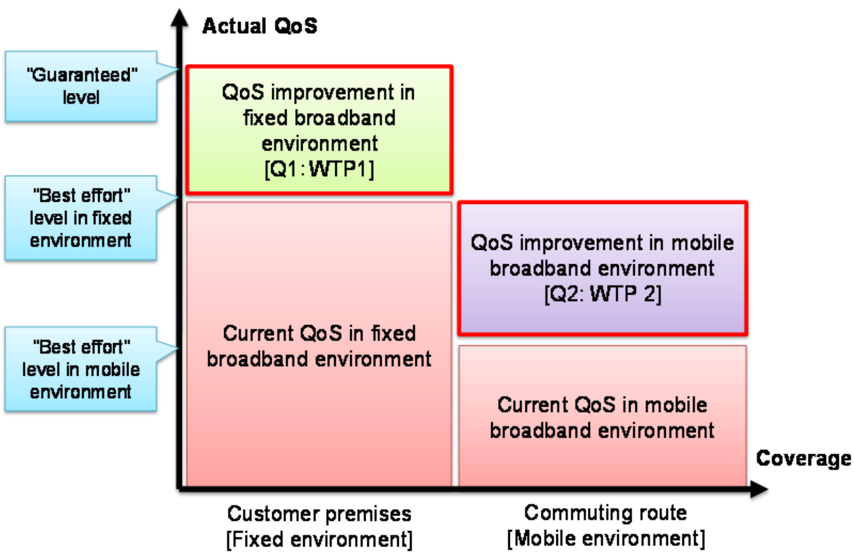


Figure 3 The relationship between WTP 1 and WTP 2

The answers to each of the above questions were statistically analyzed to calculate willingness-to-pay (WTP) figures for the respective improvements; regression analysis using various demographic variables was then conducted to identify what factors have a significant influence on WTP. If we can identify the difference in demographic factors that affect the respective WTPs, it will suggest that a mechanism determining customers' preferences on mobile broadband differs from that on fixed broadband, which will highlight the

4 http://www.speedtest.net/
5 "X" was randomly picked from 100, 500, 1000, 1,500, 2,000, 4,000, and 7,000.
6 "Y" was randomly picked from 100, 500, 1000, 1,500, 2,000, 4,000, and 7,000.

necessity of using different measures for fixed network neutrality and mobile network neutrality. The relationship between the two WTPs, "WTP 1" for Q1 and "WTP 2" for Q2, is shown in Figure 3.

Following the contingent valuation method, each WTP was estimated using a Weibull survival model. In equation 1, the survival function $S(T)$ can be interpreted as a reduced-form description of the probability that an individual's WTP is at least as high as T where μ and σ are the parameters to be estimated. When incorporating samples' demographic features, the survival function (equation 2) is applied instead, where $\mathbf{X}$ is a vector of demographic variables and $\boldsymbol{\beta}$ represents the parameters to be estimated. The demographic variables employed for equation 2 and the expected influences (shown in parentheses) on WTP are as follows: age of the respondent (indeterminable), monthly ISP fee (positive), dissatisfaction with actual download speed (positive), experience with packet congestion (positive), experience with the speed test (positive), payment for mobile computing (positive), and percentage of actual download speed over advertised download speed (negative)[7].

$$S(T) = \exp\left(-\exp\left(\frac{\ln T - \mu}{\sigma}\right)\right) \tag{1}$$

$$S(T) = \exp\left(-\exp\left(\frac{\ln T - \boldsymbol{\beta}'\mathbf{X}}{\sigma}\right)\right) \tag{2}$$

Tables 2 and 3 show the estimated results for equations 1 and 2, respectively. Table 2 shows that WTP 1 is larger than WTP 2, implying that the average user is more willing to pay to improve the fixed broadband environment than mobile QoS. Before the estimation, the author assumed that WTP 2 was significantly related to the coverage size of its QoS improvement: the wider the coverage, the more money subscribers would be ready to spend. However, the survey results fail to suggest any strong relationship between the coverage and WTP 2 except when coverage is nationwide (Figure 4). Figure 4 also shows that experiences with mobile Internet do have a positive impact on WTP 2.

Table 2 Estimated results for Equation 1

	Estimation for Q1 [WTP 1]		Estimation for Q2 [WTP 2]	
N	146		146	
N without invalid responses	102		133	
Fitness of the model				
Log Likelihood	-48.92		-55.91	
AIC	101.84		115.81	
Estimated Parameters				
σ	2.03E+00	***	1.80E+00	***
μ	6.69E+00	***	6.31E+00	***
Estimated WTP				
Mean	1648.27		924.62	
Truncated mean	1286.8		863.88	
Median	381.28		284.05	

Note 1: *** indicates statistical significance at the 1% level.
Note 2: Truncated points are 0 and 7,000 yen.

7 For technical details of the estimation process, please refer to Hidano (1999).

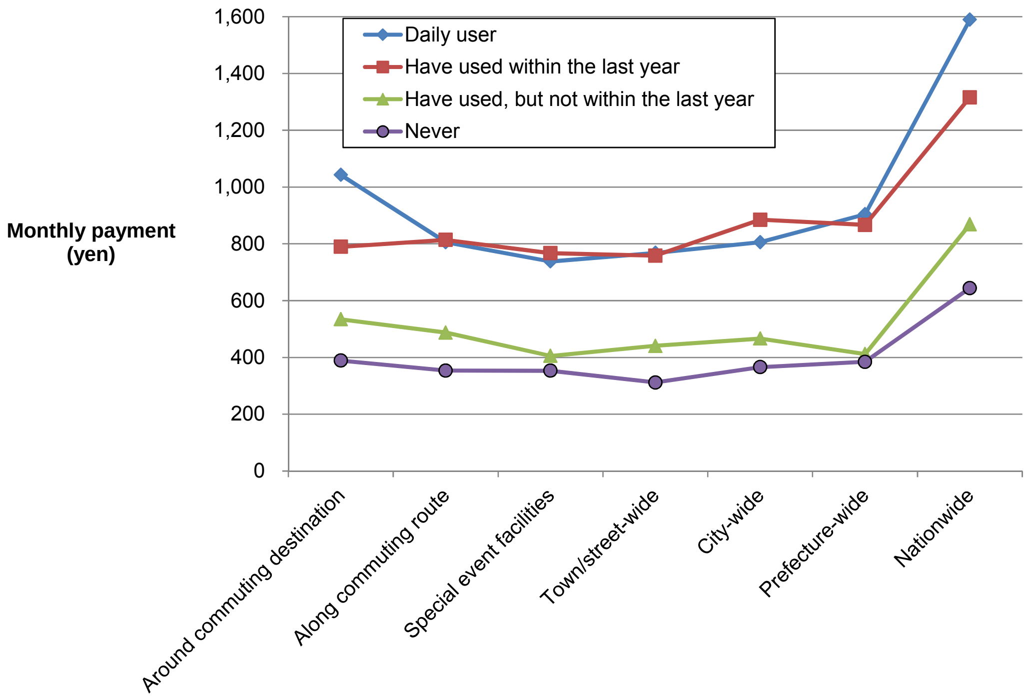


Figure 4 The relationship between WTP 2 and coverage

While not all the parameters were statistically significant, nearly all the results in Table 3 matched the author's expectations. Exceptions included experiences with packet congestion and the speed test, which require further elaboration. The most important finding shown in Table 3 is that the set of factors affecting WTP 1 is very different from the factors affecting WTP 2 at the 5% significance level. This suggests the existence of different mechanisms behind user preferences for fixed and mobile QoS.

Table 3 Estimated results for Equation 2

	Estimation for Q1 [WTP 1]		Estimation for Q2 [WTP 2]	
N	146		146	
N without invalid responses	92		122	
Fitness of the model				
Log Likelihood	-34.05		-42.03	
AIC	86.1		102.07	
Estimated Parameters				
σ	1.65E+00	***	1.44E+00	***
Age of the respondent	1.68E-01		-4.11E-01	
LN of monthly ISP fee	2.65E-02		5.95E-01	**
Dissatisfaction with actual download speed (1: not satisfied, 0: otherwise)	1.97E+00	***	5.66E-01	
Experience with packet congestion (1:experienced, 0: otherwise)	-3.26E+00	**	-1.35E+00	*
Experience of speed test (1: more than once a year, 0: otherwise)	-1.23E+00	**	5.79E-02	
Payment for mobile computing (1: paid by the respondent, 0: otherwise)	1.24E+00	*	1.40E+00	***
Actual downloading speed / advertised speed (%)	-3.13E-01		-7.13E-02	
μ	9.13E+00	***	6.61E+00	***

Note: *, ** and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.

4. Conclusion: Implications for Network Neutrality Rules

The empirical results of this paper can be summarized as follows: first, average users considered fixed QoS more important than mobile QoS, and second, different demographic factors affect WTP for fixed and mobile QoS improvements. These findings clearly suggest that it is important not to treat fixed broadband QoS and mobile broadband QoS in the same manner and that it may be beneficial for Japan to alter its approach.

However, the cost perspective of such a treatment must be considered before the MIC is persuaded to employ an FCC-like approach that has different, looser requirements for mobile broadband. One such cost is, of course, broadband providers' costs to introduce special treatments for mobile packets. Disseminating related information about mobile best-effort service and educating consumers about congestion management will be formidable challenges for broadband providers. Indeed, although 73.3% of all respondents realized that they were experienceing less than the advertised speed, only 26.6% understood the meaning of "best effort," and 72.8% did not know that there was such a term in their subscription contracts.

Another important cost relates to user perspectives. Recently, many network operators began working to provide a seamless broadband experience under the name "Fixed Mobile Convergence." This is designed to free end users from worrying about whether they are using a mobile or fixed network. Additionally, in order to address the explosive increase in data traffic, some mobile operators now actively offload 3G traffic to fixed networks using femtocell technology. Thus, it is becoming increasingly difficult for ordinary users to determine whether they are under fixed or mobile broadband network neutrality rules. If different QoS treatments are applied to fixed and mobile broadband under different tariffs for respective prioritization method, this will increase transaction costs for end users when using broadband Internet and have a negative impact on their usage experience.

To date, discussions on mobile network neutrality, in both the US and Japan, have focused primarily on the providers' viewpoint. In order to develop an optimal net neutrality rule, especially through a co-regulatory path, consumer viewpoints must also be included. However, since certain aspects of the Internet are often too technical for the public to easily understand, motivating them simply to participate in the rule-setting discussion is fruitless. The author strongly believes that increased attempts to provide basic data concerning user perspectives, such as this paper, will be required in the future.

However, the findings of this paper must be fine-tuned before they are employed for rule making. First, the theoretical framework of consumers' perceptions of broadband QoS should be firmly established. This paper showed the difference between influencing factors of QoS WTP, but it is not robust enough to determine whether the findings are unique to the respondents in the survey or applicable to the whole population. More data is needed to confirm the findings, and the development of a firm theory is necessary to explain the outcome. Second, if possible, an analysis using "hypothetical" stated-preference (SP) data should be replaced by an analysis using "actual" revealed-preference (RP) data. It is widely agreed that estimated parameters based on SP data are not as accurate as parameters based on RP data estimation; thus, we need to consider the possibility of conducting an economic experiment. Third, it may be necessary to consider variations of mobile broadband explicitly, since each application or style of usage has its own QoS requirements, which affect users' QoS perceptions differently.

Acknowledgement

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References

Cisco Systems, Inc. (2010) “Cisco Visual Networking Index – Forecast and Methodology, 2009–2014,” http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white_paper_c11-481360.pdf

Federal Communications Commission (2010) “In the Matter of Preserving the Open Internet Broadband Industry Practices,” *Report and Order*, FCC 10-201, Released December 23, 2010.

Hidano, N. (ed.) (1999) Kankyo to gyousei no keizai hyouka: CVM manyuaru (Economic evaluation of environments and policy: Manual for CVM analysis). Tokyo: Keiso Shobo.

Japan Internet Providers Association [JAIPA], Telecommunications Carriers Association [TCA], Telecom Services Association [TELESA], and Japan Cable and Telecommunications Association [JCTA] (2008) “Guideline for Packet Shaping” (in Japanese), http://www.jaipa.or.jp/other/bandwidth/guidelines.pdf

JAIPA, TCA, TELESA, JCTA, and MVNO Committee (2010) “Guideline for Packet Shaping (revised),” http://www.jaipa.or.jp/other/bandwidth/1006_guidelines_e.pdf

Jitsuzumi, T. (2010) “Efficiency and Sustainability of Network Neutrality Proposals.” In Gentzoglanis, A. and A. Henten (eds.) *Regulation and the Evolution of the Global Telecommunications Industry* (pp. 253-272). Cheltenham, UK: Edward Elgar Publishing.

MacKie-Mason, J. K. & Varian, H. R. (1994) “Economic FAQs about the Internet,” *Journal of Economic Perspectives*, 8(3), 75-96.

MIC (2011) “Estimation of the Traffic Volume in the Japanese Internet“ (in Japanese), http://www.soumu.go.jp/main_content/000109282.pdf

MIC (2010) “Competition Review in Telecommunications Business Field in FY 2009” (in Japanese), http://www.soumu.go.jp/main_content/000082463.pdf

MIC (2009) “Competition Review in Telecommunications Business Field in FY 2008” (in Japanese), http://www.soumu.go.jp/main_sosiki/joho_tsusin/kyousouhyouka/pdf/ 100519_2.pdf

MIC (2008) “Competition Review in Telecommunications Business Field in FY 2007” (in Japanese), http://www.soumu.go.jp/menu_news/s-news/2008/080905_3_bt.html

MIC (2007) “Report on Network Neutrality,” http://www.soumu.go.jp/s-news/2007/070920_6.html#bt.

Spulber & Yoo (2009) *Networks in Telecommunications: Economics and Law.* New York: Cambridge University Press.

Werbach, K. (2009) "Higher Standards Regulation In The Network Age," *Harvard Journal of Law & Technology*, 23(1), 179-225.

Wu, T. (2003) “Network Neutrality, Broadband Discrimination,” *Journal of Telecommunications and High Technology Law*, 2, 141-2003.