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Network management in the era of convergence: Focusing on application-based quality assessment of Internet access service

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ABSTRACT

As Internet applications become more sensitive to latency time, the needs for network management increase. To maximize consumer surplus and profit of Internet service provider at the same time, it is necessary to investigate the consumer's willingness to pay for a given quality of service (QoS) level. This study investigates consumer preferences for Internet access services that provide different levels of QoS for different applications. We collect stated preference data via conjoint analysis method and estimate consumer preference using mixed logit model. Based on the estimation results, we find that consumers react most sensitively to changes in the quality of the web browsing service among internet access services and have the highest marginal willingness to pay for improvements in the quality of this service. On the other hand, marginal willingness to pays are relatively low for voice over IP (VoIP) and IP television (IPTV), which are sensitive to latency time. However, if service users of VoIP/IPTV are separated from non-users or if it is assumed that there is no substitute for VoIP and IPTV, marginal willingness to pays of VoIP and IPTV increase. It implies that Internet service providers can profit by providing high QoS to VoIP and IPTV as the markets for VoIP and IPTV services mature and user numbers increase.

1. Introduction

In the initial stages, the development of the Internet was based on the fundamental principles of openness and nondiscrimination. Under these two principles, Internet service providers have provided neutral access service to all application services and end users. The open and neutral structure of Internet is the impetus for the development of various Internet applications. It is not an exaggeration to say that this has led to the recent success of the Internet.

Since this early dynamic was established, various applications have been developed in concert with the Internet. Most of the newly developed Internet application services use more bandwidth and are more sensitive to latency than earlier application services (Frischmann & van Schewick, 2007), and a wide and stable network is the most important determinant of the quality of newly developed services. Nevertheless, Internet Protocols (IPs) cannot distinguish latency-sensitive from

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latency-insensitive applications because of the basic principle of "best effort.[1]" Therefore, the role of Internet service providers responsible for quality of service (QoS) has expanded to control and manage the network to operate well (Wu, 2003). Moreover, network management is getting more important and necessary as the Internet paradigm shifts from wired to wireless because wireless Internet has limited bandwidth availability at the frequencies of interest.

With the necessity of network management by Internet service providers, the possibility for Internet service providers to abuse or misuse the management abilities has increased as well, and this has led to the network neutrality issue. Proponents of network neutrality assert that the market power of vertically integrated Internet service providers will spillover from the network layer to the application layer when the Internet service providers discriminate between non-integrated application service providers and content providers. They insist that network neutrality regulation by the government is essential because Internet service provider's discrimination will deter the development of the Internet and harm consumers and entire societies by limiting network investment incentives and stifling innovation at the application layer. On the other hand, opponents argue that vertical integration increases efficiency in the market and that network neutrality regulation is unnecessary because it reduces network investment incentives and deters innovation. Moreover, they claim that authorizing Internet service providers to manage the network will lead to the optimized development of the Internet industry.

The proponents and opponents of network neutrality could not reach a consensus, and the debate is still ongoing; the only difference is that the focus of the debate has shifted from the issues of fair competition, innovation, and network investment to "reasonable network management" since the Federal Communication Committee permitted the reasonable network management of Internet service providers. However, it is difficult to distinguish which traffic management practice is reasonable. In this case, consumer welfare can be a standard of judgment for whether a practice is reasonable or not. Many researchers (e.g., Becker, Carlton, & Sider, 2010; Yoo, 2008) consider consumers when they support or oppose network neutrality, and Jordan and Ghosh (2010) assert that traffic management practices of Internet service providers are unreasonable if they harm consumers. If the willingness to pay of consumers increases when the Internet service provider manages the QoS level without changing the price level, it indicates that the Internet service provider's practice benefits consumers. Even though the Internet service provider raises the price, the consumers' benefit can increase if the increase in willingness to pay is greater than price rise.

Nonetheless, to the best of our knowledge little research has been conducted regarding how a consumer's willingness to pay changes when the Internet service provider changes the QoS levels of applications. Hence, this study investigates which service consumers prefer among the Internet access services that provide different QoS levels for different applications. We collect data according to the conjoint analysis and estimate consumer preferences for Internet access services by using the mixed logit model.

The rest of this paper is organized as follows. The following section reviews previous literature, and Section 3 briefly explains the methodologies and estimation method used in this study. Section 4 explains conjoint analysis and describes the survey data collected by conjoint analysis method. Estimation results are shown in Section 5, and the final section summarizes and concludes the article.

2. Literature review – quality of service, quality of experience, and willingness to pay for QoS provision

According to the consumer behavior theory (McFadden, 1974), consumers obtain utility from the consumption or adoption of products or services. They choose products or services to maximize their utility subject to their budget constraint. The utility could be converted into a monetary term based on compensating variation. Therefore, consumers adopt products (or services) if the price is lower than their willingness to pay. In case of Internet products, the quality of product can be measured by quality of experience (QoE), which is defined as "the user's perception of the network's QoS parameters" by Siller and Woods (2006). QoS management of Internet service provider changes consumer QoE, and then changes a consumer's willingness to pay sequentially as stated by Lee and Kim (2014) (see Fig. 1 for the details). Moreover, as applications (VoIP and IPTV) become more sensitive to the latency time, the amount of changes in QoE and willingness to pay by QoS increases.

From the viewpoint of Internet service providers, it is difficult to forecast for Internet service providers how the change in the QoS level affects the profit if they do not know how a consumer's willingness to pay changes when they change the QoS level. For example, costs will diminish if the Internet service provider decreases the QoS level of the video streaming service because the number of video streaming packets will decrease. In contrast, it will decrease the revenue at the same time because the quality of the product will drop. Therefore, it is necessary to know the willingness to pay change due to the QoS change in order to compare the decrease in cost with a decrease in revenue.

Numerous engineering researchers have recently studied Internet QoS. Despite these studies and technological improvements, Internet QoS considers only the allocation of network resources to the requested services; it lacks consideration of the user's perception of service quality. Therefore, it has yet to be implemented with a definite standard. Instead, Internet QoS has recently become a sensitive issue in the study of social science, and it is widely perceived that consumer evaluation should be implemented before setting up QoS.

[1] "Best effort" refers to the transmission of information packets without discrimination.