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A progressive analysis of Internet market: from best effort to quality of service

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Abstract

In this paper, the equilibrium outcomes of the Internet quality of service (QoS) game model are analyzed when two rural Internet Access Providers (IAPs) interact with several business and technical strategies such as technology, best effort (BE) or QoS, pricing scheme (flat-rate pricing or a two-part tariff), and investment in network capacity. Considering the IAPs with BE and flat-rate pricing as the current Internet, the equilibrium points in this model show a progressive path of market behavior toward the future Internet market. In conclusion, the IAPs with a strategy set of {QoS, flat-rate pricing, 2K network capacity} would be a plausible and socially desirable market situation in the future.

Keywords: Internet QoS; Game theory; Simulation; Equilibrium; Social welfare

1. Introduction

After the commercialization of the Internet in 1995, the demand for various Internet services diversified. New real-time and business-critical data applications require improved levels of services, or 'quality of service (QoS)', from the network. In the current Internet, most traffic is treated indifferently: there is no discrimination among Internet traffic streams, there is only one class of service (CoS) to which all traffic belongs, there is no delivery confirmation and no

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guarantee for timely delivery, and there is a possibility for traffic loss. This kind of Internet service is called 'best effort (BE)'. Compared to BE with no service classification, QoS has various classes: a class for guaranteeing timely delivery, a class for no traffic loss, and a class for delivery confirmation. The relationship between BE and QoS is similar to that of regular mail and priority mail as the users pay a higher price for the priority service than the regular service (Black, 2000). However, guaranteeing QoS in the Internet is not easy. The main reason is that even though Internet Service Providers (ISPs)[1] are using the common TCP/IP protocol, they are different in terms of backbone capacities, network architectures, routing protocols, business models, etc. Furthermore, there is no single entity to coordinate the whole Internet industry. Therefore, end-to-end QoS guarantee is impossible without the stronger coordination of multiple ISPs in the Internet industry, because any QoS assurances are only as good as the weakest link in the chain between the sender and the receiver.

In the summer of 2001, large service providers like AT&T and WorldCom announced that they would provide Internet "CoS" to their customers. The Class of Service (CoS) consists of four classes according to priority level: platinum, gold, silver, and bronze. For example, voice or video applications can get the highest priority, while other traffic, such as E-mail or HTTP, can be given the lowest priority, which is the same class as the current Internet. Since QoS interconnection policies have yet to be established, this CoS capability is limited to traffic that is contained completely in the provider's own network. Table 1 describes the characteristic of each class.

To address this limitation, BellSouth's Florida Multimedia Internet Exchange (FMIX) announced a plan in 2001 to be the first Network Access Point (NAP)[2] to support QoS interconnection using Multi-Protocol Label Switching (MPLS).[3] Some of the challenges (that were not in the announcement) lie in determining how class matching between providers will be achieved and disclosing the necessary network information for an end-to-end quality guarantee without compromising the competitive position of the interconnecting parties.

Despite these difficulties, it is certain that, in the not-too-distant future, QoS will be introduced not only in private networks but also in the entire Internet. The backbone market leaders' movement toward QoS and the emergence of QoS-enabled NAP are considered to be strong signs of this shift. Other features of this new network include:

(1) *Product diversification*: Before QoS, there was only one available service level, i.e., BE, in which traffic delay and traffic dropping were possible. With QoS, there are two services in the Internet market: a BE service and a QoS service. Since the QoS service includes the BE service as its lowest CoS, the new markets will feature vertical product differentiation.
(2) *Operational transition*: Traditionally, IAPs[4] in the US provided flat-rate access plans and later performed a limited amount of usage metering. Previous research (MacKie-Mason & Varian,

[1] The term ISP in this paper includes Internet Access Provider (IAP) in the Internet access market and Internet Backbone Provider (IBP) in the Internet backbone market.

[2] A NAP is where Internet interconnection among different providers occurs.

[3] MPLS is a label swapping (mapping) and forwarding technology. The idea of MPLS is to improve the performance of network layer routing and the scalability of the network layer.

[4] A company that provides access to the Internet IAPs generally provide dial-up access through a modem and PPP connection, though companies that offer Internet access with other devices, such as cable modems or wireless connections, could also be considered IAPs. The term IAPs and ISPs are often used interchangeably, though some people consider IAPs to be a subset of ISPs (*source*: www.webopedia.com/TERM/I/IAP.html).