Internet Telephony and Its Impacts on Long Distance Voice Services

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Acknowledgement

The author wishes to thank Mr. Jungsu Song, the Senior Officer, Ministry of Information and Communication, the Republic of Korea, for his contribution of ideas and comments and the kindest help in raw material research and to Mr. Gwang-Syung Hwang for his assistance in editing. Any remaining errors should be solely attributed to the author.

Abstract

The Internet has been a network of computer networks. In the near future, the Internet will provide integrated services that combine audio and video appliances. Internet telephony (IT) represents a viable example of this extended Internet. IT indeed poses a potential threat to toll service provided through Public Switched Telecommunication Networks (PSTNs) because of its substitute quality and competitive prices. This paper is then written to analyze the impacts of IT on PSTNs in three parts: 1. the potential competitiveness of IT vs. PSTN long distance, 2. the possible consequences of imposing interconnection charge on IT vs. PSTN long distance, and 3. the potential threat to the collection of the accounting rates applied on international voice telephony. The paper first briefs the technologies and the architecture of IT, and it constructs the cost models of IT in comparison with that of toll service following the discussion of the technologies. It then predicts the substitution effects between IT and toll service, provided that IT is exempted from the current pricing structure of interconnection charges. The paper finally concludes that the availability of IT indeed causes a bypass from PSTNs, which results in an unsustainable collection of the accounting rates. The perfectly substitute IT with a lower price then presses the need for renegotiation

about the accounting rates among countries .

I. IT Components and Quality Differentiation

There are three currently available IT technologies that allow the transmission of telephone-like digital conversations through the Internet. First of three is Computer-To-Computer IT. The IT software compresses the sender's voice signal, and packages the data into packets that can be sent over the Internet (currently using the User Datagram Protocol, UDP) to a local Internet Access Provider (IAP). At the receiving end, the *procedure is the same: the packets are converted back into audiosignals and routed it through the sound card* to a speaker. The second one is Computer-to-Telephone Technology (Phone Gateway). The phone gateway is a computer that bridges the gap between the telephone network and the Internet by converting analog voice signals to packets for the Internet (Dialogic, 1997). At one side, the gateway connects to the telephone world; at the other side, the gateway connects to the Internet world. The third one is Phone-to-Phone Technology. By coupling two phone gateways, phone calls between two regular phones could be placed through the Internet. One gateway digitizes and compresses the analog signals, and formats the data into Internet packets and rout them to the Internet; the other gateway in the destination city converts the received packets back into voice and sends them through the standard PSTNs[(1)] .

Best Effort and Guaranteed IT

At present, IT services are not reliable compared to PSTN telephony due to their "best effort" protocols that currently govern the Internet architecture. The best effort model does not reserve a fixed amount of bandwidth during data transmission like PSTNs so that packets could be dropped if the traffic over the Internet is congested. While this model may work well enough for non-real time applications such as e-mail, it can result in an unacceptably poor level of quality for real-time applications such as telephony. Newer protocols such as Resource ReSerVation Protocol (RSVP) and Asynchronous Transfer Mode (ATM) are developed to support the real-time applications over the Internet by providing resource reservation and service guarantee (Bhatia, 1997 and Borden, 1995).

IT essentially splits the market into two segments, that is, one with sound quality and reliability and easy-to-use service through traditional circuits switching methods and the other for low-cost service by packet switching over the Internet. Expectedly, these two services are not substitute for each other: one is the best effort IT and the other is guaranteed IT. The customers who have a lower demand for service quality are willing to subscribe the best effort IT; however, the customers who have a higher demand for service quality will not subscribe the best effort IT even if its price is cheaper. Instead, the customers with high-quality demand are likely to choose the guaranteed IT at a higher price. Comparing IT with PSTN telephony, only the high-quality guaranteed IT could compete with PSTN telephony because of comparable quality terms and easiness to use. Currently, long distance phone calls are made by connecting to an IXC's point of presence (POP) through a local central office, while IT is made by connecting through the local central office to the Internet accesses like ISPs or Gateway. This ISP/Gateway can be considered an Internet point of presence

(IPOP), analogous to POP.

II. Cost Structure of IT and PSTN Long Distance

Economies of scope and scale inherent in telecommunications services make their cost structures more complicated than the perfect competition model where cost-based pricing is adopted. Because the average cost of providing telecommunications services is above the marginal cost, telecommunications service providers are unable to recover the total cost if charged on the (marginal) cost-based pricing. Bridger Mitchell et al.develop a model of "average incremental cost" for pricing telecommunications services. Incremental costs are the costs incurred by adding an output increment, ranging from infinitesimal to a whole set of outputs; average incremental costs (AICs) are the incremental costs divided by the quantity of the service provided (Mitchell et al, 1995:103). The incremental cost of providing an extra telecommunications service usually includes additional networking capacity, overhead operation management costs, the cost of conditioning the system compatibility, and the marginal cost of per-unit service (Mitchell et al, 1995:103). In this case, AIC is greater or equal to MC but is smaller than its stand-alone average cost (i.e., the same as AC when the service is offered alone). Based on the architectures discussed in Section I and above economic modeling of AIC, we build hypothetical models for IT and PSTN long distance to compare their AICs.

1. Best effort IT, Guaranteed IT vs. Toll Service

We begin the cost analysis by assuming the "send-and-keep" approach applicable to IT as well as to PSTN long distance, that is no interconnection charge counted as part of their costs. The total cost of providing the best effort IT is the sum of the cost of shared portion of local loops, fixed cost of IPOP and backbones, management and operation cost, and marginal cost of data transmission. Since local loops are also constructed to provide other services, it is not counted as part of IT's incremental cost.

The total incremental cost of the best effort IT (ICbIT) is:

TICbIT = IPOP + backbones (B) + management/operation cost (M) + transmission cost (2*c*q)

$$TICbIT = IPOP + B + M + 2cq \quad (1)$$

c is marginal cost of data transmission over the Internet, q is the given output of calling minutes, and 2c indicates that the delivery of the IT packets costs as twice as regular data packets. Because the former are converted and transmitted through IPOP or Gateway that also serve as another Internet access point, the traffic and its cost are doubled (Sears, 1996a).

The average incremental cost of the best effort IT per minute (AICbIT) becomes ICbIT divided by q.

$$AICbIT = TICbIT/q = (IPOP+B+M)/q + 2c \quad (2)$$

Because the guaranteed IT requires reserved bandwidth to accomplish ATM protocols, its incremental cost (TICgIT) is TICbIT plus the bandwidth cost:

TICgIT = IPOP + backbone (B) + reserved bandwidth (R) + management/operation cost (M) + transmission cost (2cq) applying (1)

TICgIT = IPOP + B + R + M + 2cq == (IPOP+B+M+2cq) +R = TICbIT + R (3)

Again, the average incremental cost of the guaranteed IT per minute (AICgIT) is TICgIT divided by q.

AICgIT = TICgIT/q = (TICbIT + R)/q = TICbIT/q + R/q = AICbIT + R/q (4)

From (4), we can tell that AICgIT is higher than AICbIT by R/q.

The total incremental cost of PSTN long distance (ICLD) is as follows:

TICLD = POP + long distance loops (L) + management/operation cost (M') + switching cost (s*q)

TICLD = POP + L + M' + sq (5)

s is the marginal cost of switching voice calls over PSTNs, q is the given output of calls

The average incremental cost of toll service per minute (AICLD) is ICLD divided by q

AICLD = (POP + L + M')/q + s (6)

2. Substitution Effect and Social Welfare

A. the guaranteed IT vs. the best effort IT

Because AICgIT is higher than AICbIT by R/q, the market price of the guaranteed IT at the given q output, PgIT, is higher than PbIT of the best effort IT by R/q (Diagram 2.1). However, the price difference does not cause the substitution effect in between due to the fact that their quality difference divide them into two different markets.

B. the best effort IT vs. toll service

Because the best-effort IT has a lower quality of service compared to PSTN calls, it will not be substitute for toll service and the customers who have a higher demand for satisfactory quality will continue to subscribe toll service. The best effort IT, in this sense, only appeals to the group of customers with a lower need for quality but demanding for lower priced services. As long as its marginal cost is below or equal to the marginal utility the consumers obtain, they who would otherwise never purchase any telephony will subscribe the service. In Diagram 2.2, the market equilibrium is at a if without the best effort IT, which is accompanied by a deadweight loss of the black shaded area. The deadweight loss results from the fact that the low demand group are not served by PSTN long distance. But by offering the best effort IT, the low demand group obtains the consumer surplus of the dotted area. The best effort IT is charged P2 at which the average incremental cost is equal to the marginal revenue and generates the q2 output. The deadweight loss is then reduced to [the black shade area - the dotted area]. In other words, the provision of the best effort (low-quality) IT will not affect the PSTN long distance market but increases social welfare by reducing the deadweight loss.

C. the guaranteed IT vs. PSTN long distance

As discussed above, only the guaranteed IT could compete with PSTN telephony because of comparable quality terms and easiness to use. The substitution effect then takes place between the guaranteed IT and toll service. The substitution effect is indeed determined by their relative price (cross-price elasticity) that depends on their cost function. Back to (4) and (6), marginal cost of data transmission c and the marginal cost of switching voice calls are about zero without network congestion. The cost difference of the guaranteed IT and PSTN long distance at a given q output is

(4) -(6) = [(IPOP+B+M+R)-(POP+L+M')]/q = [(IPOP-POP) + (B+R-L) + (M-M')]/q

= [(technological cost difference) + (management cost difference)]/q

In this case, the cost difference of the services depends on the productive efficiency of the service providers (i.e., efficiency in technological innovation and management). Provided that the ISPs are more efficient than the IXCs in providing the service, their cost is smaller than that of the IXCs (i.e., AICgIT < AICLD). In Diagram 2.3, the increased efficiency of the ISPs enables the relative price of the guaranteed IT to of PSTN long distance to drop. As a result, the demand for the guaranteed IT increases from Y1 to Y2; while the demand for the POTS decreases from X1 to X2. The outcome is vice versa if the IXCs are more efficient than the ISPs. Our analysis does not confirm the ISPs' allegation that they have lower AICs than the IXCs and are more capable of providing telephone services. Instead, our analysis shows that their cost difference depends on their improvement in productive efficiency. Without interconnection charges, the IXCs and the ISPs can compete with each other by employing the most efficient technology and management in their production. If either party in competition cannot adjust its cost function, it is comparatively more inefficient and eventually will be driven out of the market. We assume viable technological investment and operation in the long run, therefore, the IXCs and the ISPs will achieve their long term efficiency in competing each other. That is to say, their long run productive efficiency (AICs) should be about the same.

III. Interconnection Charge

The above analysis assumes no interconnection charge in both the guaranteed IT and toll service. In reality, the IXCs pay access charges to the LECs for their terminating national toll calls and pay settlement rates (i.e., half of the accounting rates) to the carriers in other countries that terminate international toll calls, while the ISPs are not required to pay interconnection charge based on the send-and-keep approach that compensates transmission of the Internet traffic. As interconnection charge is part of the IXCs' costs, we now remodel our analysis to incorporate interconnection charge and reexamine its impact on the substitution effect between the guaranteed IT and toll service.

Suppose both the ISPs and the IXCs are required to pay the LECs (or international carriers) for originating and terminating their calls, their new cost structure (AICgITr for the guaranteed IT at a per-minute basis and AICLDr for PSTN long distance at a per-minute basis) becomes AIC plus the interconnection charge per minute (rgIT for the guaranteed IT and rLD for PSTN long distance).

AICgITr = AICgIT + rgIT (7)

AICLDr = AICLD + rLD (8)

As discussed above, both long term AICs are the same (i.e., AICgIT = AICLD) provided that the ISPs and the IXCs can compete with each other in the long run. Therefore, the interconnection charges imposed on the ISPs and the IXCs determine the cost difference and the magnitude of substitution effect. If rgIT > rLD, then AICgITr > AICLDr (i.e., (7)-(8)>0). As a result, the relative price of the guaranteed IT to that of toll service rises and customers stay with the switched telephone service. In case that rLD is larger than rgIT, AICgITr < AICLDr (i.e., (7)-(8)<0). The relative price of the guaranteed IT to toll service drops and the customers divert to the IT. In this sense, the IXCs must reduce its technological and management costs in order to compete with the ISPs, that is, AICgITr = AICLDr.

Suppose rLD = t*rgIT > rgIT, t>1 (9)

then the following condition must be met:

AICgITr = AICLDr

AICgIT + rgIT = AICLD + rLD = AICLD + t*rgIT (10)

make AICLD = e(AICgIT), 0<e<1, e is the efficiency indicator

then AICgIT + rgIT = e(AICgIT) + t*rgIT

In other words, the IXCs must be e times efficient than the ISPs to compete for market share when rLD is t times beyond rgIT. Cinerman and Waldau's study corroborates that entrants with huge interconnection charges must be extraordinarily efficient to compete with the incumbent.[(2)] If the interconnection charge to the IXCs is excessive compared to that of the ISPs, the IXCs have substantial burderns to reduce their technology and management costs.

The FCC concludes in the *Local Competition Order* that rates levels of the access charge appear to significantly exceed the AIC of providing the interconnection services.[(3)] Because the cost of interconnection (s) or data transmission (c) is not traffic-sensitive (i.e., the usage-based pricing), the marginal cost of interconnection per minute is essentially zero. The present rate of the access charge to the IXCs is about 5.7 per minute that substantially exceeds the zero marginal cost of interconnection. The accounting rates for originating and terminating international toll service are decided by negotiations among international carriers, ranging from 17 per minute in US-British traffic to $ 2.34 per minute in US-Indonesia traffic. The excessive accounting rates imposed on international toll service, again, are substantially above the zero cost of interconnection. In contrast to the send-and-keep approach adopted in the Internet in which the ISPs are not required to pay interconnection charge to the LECs or international carriers, the access charge and the accounting rates imposed on the IXCs places them at a disadvantangeous position in competing with the ISPs. Since the price of toll service remains reasonably high due to the access charge and the accounting rates, customers will switch to the guaranteed IT. In Diagram 3.1, the price of long distance calls is raised to P2 because of access charge/accounting rates; whereas the guaranteed IT is priced at lower P1 without the access charge/accounting rates. As a result, the customers turn to subscribe the guaranteed IT.

IV. Conclusion

The above economic analysis leads us to conclude that, first of all, the provision of the best effort IT can improve the social welfare status because the low demand customers are better off in exchange low quality with lower prices. Secondly, the guaranteed IT and PSTN long distance can compete with each other, which depends on their long run technological and management efficiency. As far as the access charge and accounting rates are concerned, any charge departing from the marginal cost of interconnection will impose competitive disadvantages on the IXCs in competing with the ISPs. The accounting rates especially render the IXCs extra cost burdens that cause price of international toll service apparently much higher than that of the guaranteed IT. Unless the IXCs extremely improve their technologies and management, they cannot reduce the price of international toll service. Consequently, the international long distance customers will switch to the guaranteed IT.

The guaranteed IT inevitably challenges the viability of the collecting mechanism of accounting rates. The question we are left with is how to revise the system of international accounting rates under technological devolution of computer and communications services. Although this paper does not address the alternatives to compensate the transmission of international voice traffic, it builds a foundation for further research on this issue with respect to technological evolution.

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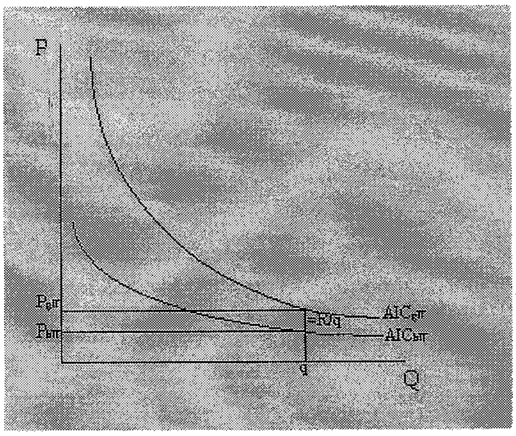
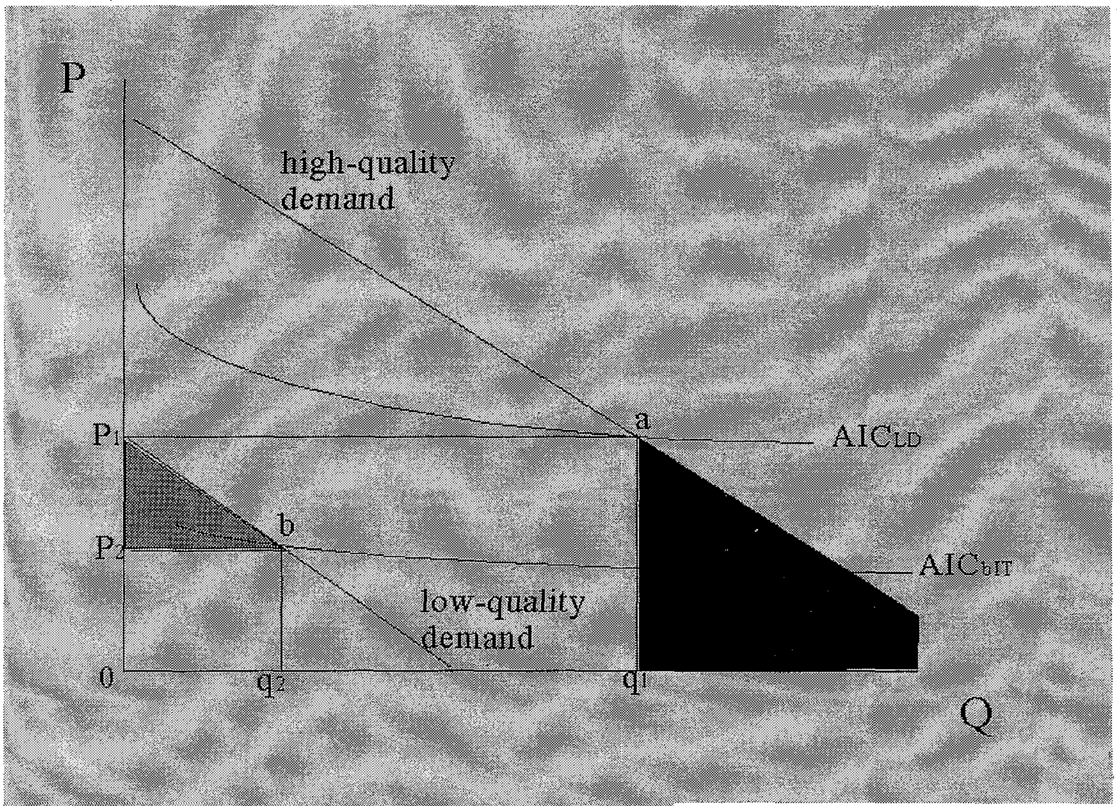
1. There is an upcoming IT technology, so called as Direct Dialing IT. Providing IT directly into the home would represent the final level of innovation. It would be much like regular telephone. Every home is connected to the Internet through Local Area Network (LAN) and home computer acts as a smart PBX, which could route phone calls either through the Internet or the PSTN without the end users knowing how the call was routed. This would allow for direct dialing IT as opposed to dialing into a phone gateway, which could make IT almost indistinguishable from circuit switched service

2. When the entrant is charged .5 (dollar) per call for interconnecting the incumbent's local loops, e is calculated as .88; whereas e becomes .58 as the charge raises ten times to 5. It means that the entrant must be almost as twice efficient as the incumbent when charged high interconnection fees (Cineman & Waldau, 1995:126-31).

3. *Implementation of the Local Competition Provisions of the Telecommunications Act of 1996*, CC 96-98, FCC 96-325 (released August 8, 1996) (*Local Competition Order*).

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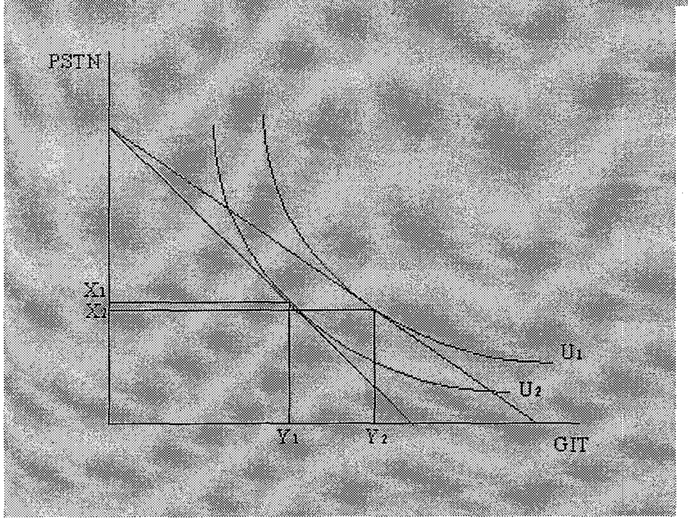
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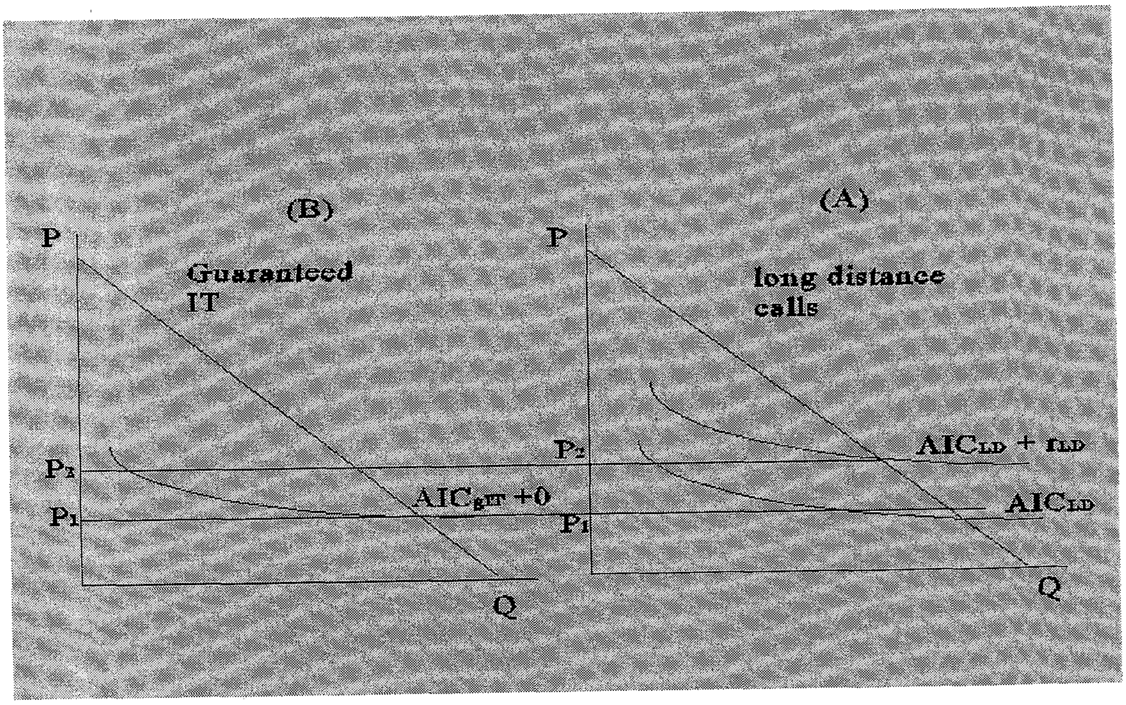

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