Cross-User Subsidy in Residential Broadband Service

by

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Bachelor of Science in Electrical Engineering
Seoul National University, Korea, 2002

Submitted to the Engineering Systems Division and the
Department of Electrical Engineering and Computer Science in
Partial Fulfillment of the Requirements for the Degrees of

Master of Science in Technology and Policy and
Master of Science in Electrical Engineering and Computer Science

at the
Massachusetts Institute of Technology
September 2005

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ABSTRACT

The rapid growth of Internet traffic has made Internet Service Providers (ISP) struggle to upgrade network capacity and to maintain service quality. The increase in the broadband usage impacts the cost of an ISP through usage-associated costs such as incremental usage cost, cost for expanding the network capacity, and cost from subscriber churns. This paper attempts to understand the relation between broadband usage and incremental usage cost.

This thesis addresses issues on connecting the broadband usage to the usage-sensitive costs. How much do the light users spend to support the heavy users by paying the equal usage fee? To answer the question, it should be investigated how much incremental cost is generated by using networks and how the traffic load is distributed over the users.

The research is based on the commercial broadband usage data sample and the published financial statements from a major broadband service provider in Korea, Korea Telecom. Analyzing the broadband usage reveals to us what the usage distribution looks like and how the distribution evolves over time. By examining the published financial data, the cost directly associated with the broadband usage is estimated. The usage distribution and the estimated cost is incorporated to find an answer to how much burden the light users are carrying to subsidize the heavy users on the network under the current flat usage fee system.

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ACKNOWLEDGMENTS

I would like to sincerely express my gratitude to Dr. David Clark. His academic knowledge, intuitive explanation, and patient encouragement led me to have insights as well as knowledge in the research. I am deeply indebted to my colleague, Steve Bauer, for sharing his research experiences. He helped me set up the research topics and focus on them. I am also grateful to the Senior Vice President of KT Corporation, Won-Pyo Hong, not only for offering the usage data sample for this research but also for sharing his forward-looking vision in telecommunication industry.

I also would like to thank Sidney Miller for always taking care of TPP students and me. Whenever I had problems at school, she guided me to the best solutions.

Special thanks to my friends in TPP, EECS, PALS, and Ashdown that gave me wonderful memories.

Finally, I would like to thank my family, especially my parents and my grandmother in Korea and my aunt in NJ, for supporting and encouraging me.

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CHAPTER 1 INTRODUCTION

1.1 Motivations

As residential broadband access becomes widespread, Internet Service Providers (ISPs) are struggling to upgrade network capacity and maintain service quality under dramatically increasing data traffic loads. The rapid growth of Internet traffic is caused by both an increasing number of broadband subscribers and an increasing amount of data transfer by the subscribers. While the number of subscribers was growing fast, the ISPs were able to profitably increase an associated infrastructure to meet the increasing demand for bandwidth. However, as the market becomes saturated and individual users demand more bandwidth, it is not economically viable either to expand network capacity without correspondingly increasing revenues or to manage networks without reducing usage-sensitive costs.

An increase in broadband usage, either from the number of subscribers or the number of individual usage, impacts the cost of an ISP in several ways. First, it increases a usage-sensitive operating cost that is not easy to pass on to subscribers. Next, the growth in traffic results in a large capital expenditure to expand network capacity. Finally, frequent traffic congestion in an ISP is likely to induce subscribers to switch to another ISP and result in the cost of churning.

There have been various efforts to cope with the dramatic growth in broadband usage and associated costs from different perspectives. From a technical point of view, ISPs introduce various engineering methods such as traffic measuring and shaping to manage the network traffic loads. In addition, ISPs try to improve the Internet interconnection cost through peering methods. On the business strategy side, ISPs try to reduce the usage-sensitive cost by using a cap to limit user traffic or to increase the revenue by introducing differentiating pricing schemes.

In any strategies to deal with the usage-sensitive cost or even pricing, the first effort to be done is to understand the broadband usage and the associated costs. As a first step, we need to estimate the usage-sensitive cost by examining the published cost profile of an ISP. Today, the usage-sensitive cost is equally charged to the users through the monthly flat fee, whereas the cost is generated depending on the usage of the users. As a result, light users come to support heavy users under the flat pricing scheme. Thus, we attempt to determine the subsidy effect across the users based on the usage distribution.

1.2 Objectives

This thesis addresses important questions about broadband usage and the usage-sensitive costs. How much do the light users spend to support the heavy users by paying the equal usage-sensitive fee? Prior to approaching the question, two key issues should be investigated: How much usage-sensitive cost is generated in terms of dollar per byte and is charged in terms of dollar per user? How is the traffic load distributed over the users?

The research is based on the commercial broadband usage data and the published financial statements from a major broadband service provider in Korea, Korea Telecom (KT). By analyzing the broadband usage, what the usage distribution looks like and how the distribution evolves with time will be explored. By examining the published financial data, the cost directly associated with the broadband usage will be estimated. The usage distribution and the estimated cost will be incorporated to find an answer to how much burden the light users are carrying to subsidize the heavy users on the network under the current flat pricing system.

1.3 Thesis Outline

We start with a brief background of the residential broadband service and describe the competitive environment in the Korean broadband market. The figures and tables in chapter 2 show how the broadband market has evolved over time. In chapter 3, the cost structure in providing broadband service will be investigated. Especially, we discuss the cost associated with the broadband usage and estimate the usage-sensitive cost based on the published financial data. In chapter 4, we then move on to analyzing the distribution of the broadband usage and notice a shift toward heavier usage in average traffic trend. Finally, we point out the rise of cross-user subsidy between heavy users and light users under the flat usage fee scheme in chapter 5. Based on the usage distribution of chapter 4 and the usage-sensitive cost of chapter 3, the cross-user subsidy for the usage-sensitive cost is estimated. We conclude with analyzing possible ways to reduce the subsidy effect across subscribers in chapter 6.

CHAPTER 2 BACKGROUND IN BROADBAND SERVICE

2.1 Overview of Broadband Service

The Internet started as a federally funded project to develop fault-tolerant systems for reliable communication. There have been two federally funded upgrades of the main Internet backbone, one in 1986 and the other in 1988. As of the Telecommunication Act of 1996[1], all federal funding for the Internet backbone has been stopped and the Internet became a completely private enterprise. There is no single backbone now, and it is a conglomeration of backbones developed by AT&T, MCI, Sprint, and etc.

Most organizations including individual users do not connect directly to the Internet backbone. For example, an individual user typically connects to its local access network which is an Internet service provider (ISP), and the ISP connects to the Internet backbone through their backhaul links. Most ISPs charge their residential subscribers for access, but not for actual usage. Therefore, today's ISPs face significant usage-associated cost that is not easily passed on to subscribers in order to maintain the quality of the network as the demand for bandwidth grows.

2.2 Broadband Market in Korea

With the rapid growth in the broadband service industry, Korea is one of the leading countries in the world in terms of broadband penetration ratio of 76.7% in March 31, 2005. Broadband Internet penetration rate is calculated by dividing the number of broadband Internet access service subscribers by the number of households. According to the Ministry

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[1] The Telecommunication Act of 1996, Federal Communications Commission, <http://www.fcc.gov>

of Information and Communication in Korea, the number of the broadband Internet access subscribers is 12.1 million in total as of March 31, 2005. According to the OECD statistics, Korea leads the countries in the OECD in broadband penetration with 24.9 subscribers per 100 inhabitants while the average OECD broadband penetration rate reached 10.3 subscribers per 100 inhabitants in December 2004.

Due to the competitive environment in Korean broadband access market, broadband subscription fees are relatively low in respect to the high speeds. Basic service speeds begins at 1 Mbps up to 4 Mbps, and premium offers range from 8 Mbps to 20 Mbps. In 2004, VDSL technology with speeds of up to 50 Mbps became commercialized and the broadband Internet service providers introduced wireless LAN service with speeds of up to 54 Mbps. Table 2.2.1 shows a comparison of fees across the Korean Internet service providers in the two representative broadband services with three year mandatory subscription period in March, 2005[2].

Table 2.2.1 Price Comparison of Comparable Broadband Services in Korea

ISPs	Modem Technology		Monthly Subscription				Monthly Modem Rental	Initial Installation	Additional Installation
			Basic		Premium				
KT	DSL		$24.6		$32.8		$2.9	$29	$9.7
Hanaro	DSL	Cable	$24.3	$24.3	$32.7	$29.6	$2.9	$29	$9.7
Thrunet	Cable		$23		$31.2		$2.9	$29	$17.4

There are three large providers in broadband access market in Korea: KT, Hanaro, and Korea Thrunet. The most dominant ISP is KT (Korea Telecom). The price of KT's basic

[2] The conversion of Won into US Dollars in this paper was made at the noon buying rate in effect on December 31, 2004, which was Won 1,035 to USD 1.00.

DSL service is about $25 per month with unlimited data transfer and a peak speed of 4 Mbps for download. The next higher offering service costs about $33 per month for a 13 Mbps service. Hanaro Telecom is the second largest broadband provider in Korea providing both DSL and cable modem services. Hanaro's basic DSL service is about $25 for a 4 Mbps speed with unlimited data transfer. Hanaro's 13 Mbps service in DSL is similar to KT's 13 Mbps service in price while its 10 Mbps service in cable is cheaper than Thrunet's 10 Mbps service. The final major broadband provider is Thrunet[3] that primarily offers cable modem services. The basic service costs $23 per month and provides 4 Mbps peak rate with unlimited data transfer. The premium service with 10Mbps is priced about at $31.

Table 2.2.2 Market Share of Major ISPs in Korea

	KT	Hanaro	Thrunet	Cable Providers	Others
2002	47.3%	27.6%	12.6%	5.2%	7.4%
2003	50.0%	24.4%	11.6%	7.1%	6.9%
2004	51.0%	23.1%	10.8%	9.0%	6.1%

As the market has rapidly become mature in terms of the number of broadband subscribers in Korea, the total revenue of a broadband access service company have faced a flat lining revenue stream. Figure 2.1.1 and Figure 2.1.2 show that the broadband market in Korea is becoming saturated in terms of the total revenue and the number of subscribers[4]. After the

[3] It has been reported that Hanaro has entered into a memorandum of understanding to merge with Korea Thrunet and is currently waiting for a court order ending the court receivership of Thrunet in order to finalize the merger.

[4] Korea Association of Information and Technology <http://www.kait.or.kr>

explosive growth in broadband service market during 2000, the increase in the number of subscribers and the total revenue slowed down.

Figure 2.2.1 Total Broadband Revenue and Growth Rate in Korea

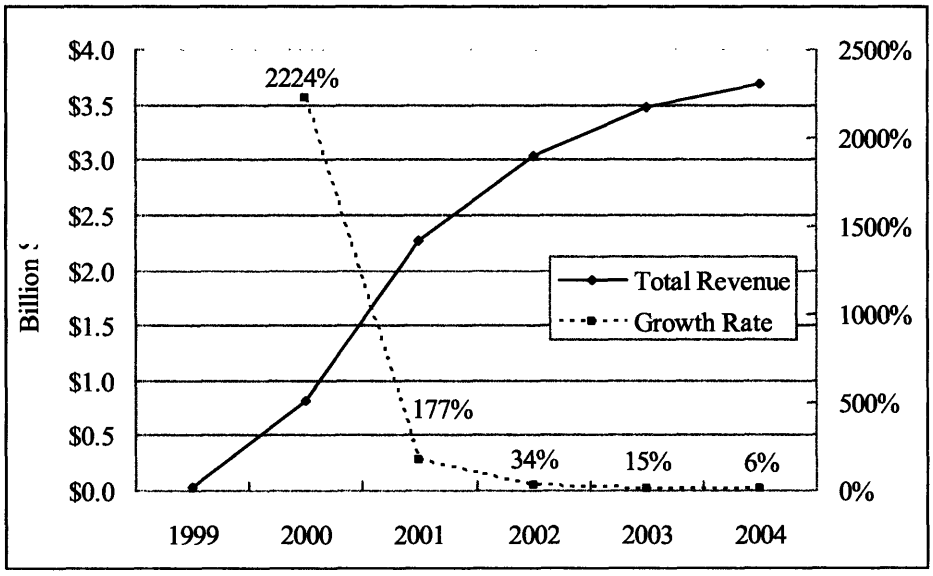
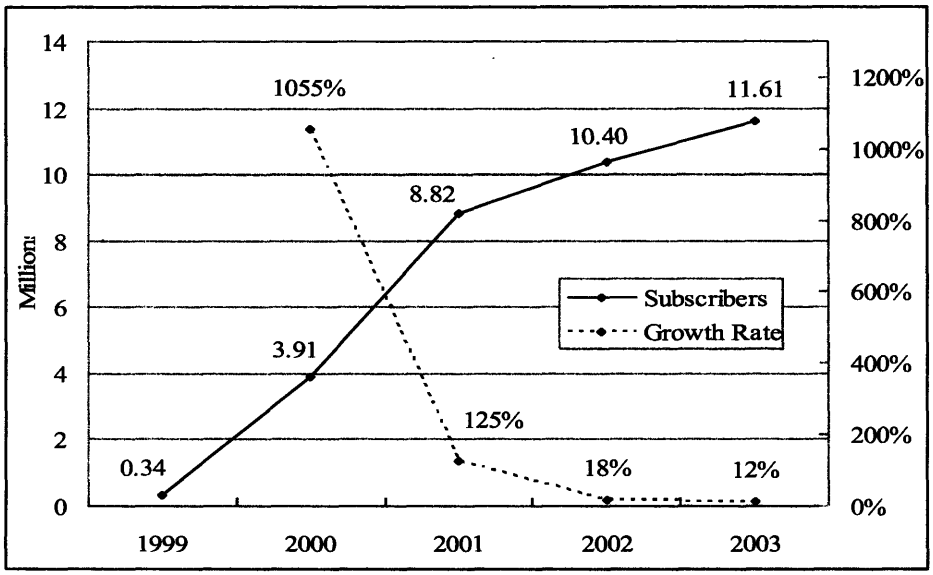


Figure 2.2.2 Broadband Subscribers and Growth Rate in Korea



2.3 Korea Telecom

KT is the largest telecommunications service provider in Korea in the areas of telephone services, broadband internet access services, mobile telecommunication services, and other related communication services. KT's traditional business has been focused on fixed line telephone services and recently has entered into the broadband Internet access services and mobile telecommunication service.

Currently, KT is the dominant provider of broadband access services in Korea with 50.7% market share based on 6.1 million subscribers as of March 30, 2005. Primary broadband access services that KT offers are Megapass Lite and Megapass Premium. If we look at the data on revenue and subscribers for the services in Figure 2.3.1 and Figure 2.3.2, we can observe that the broadband market for KT is also becoming saturated.

Figure 2.3.1 Revenue and Growth Rate in the Megapass Service of KT

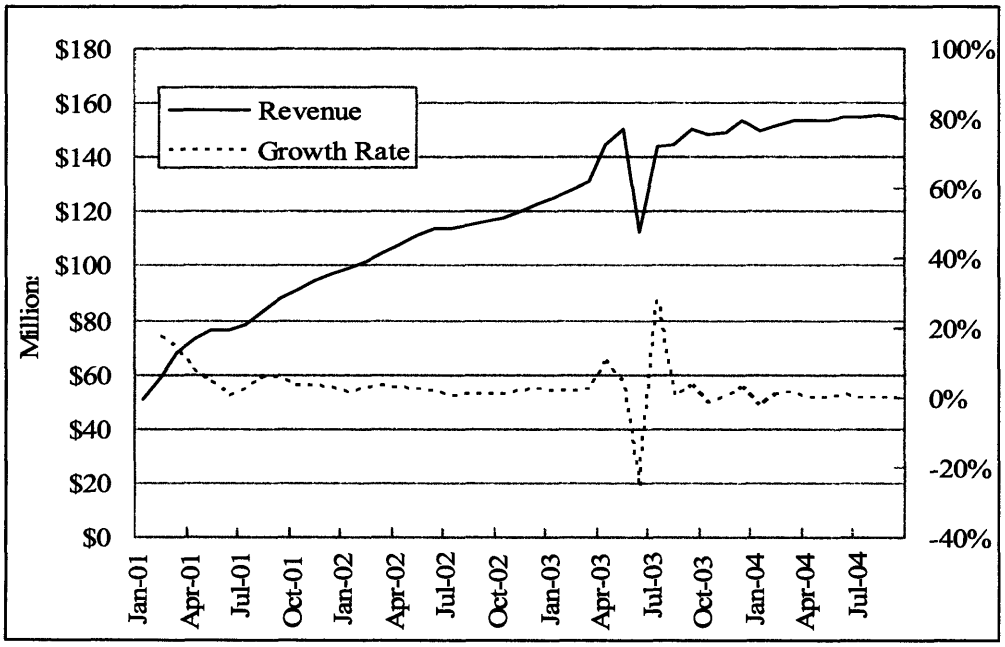
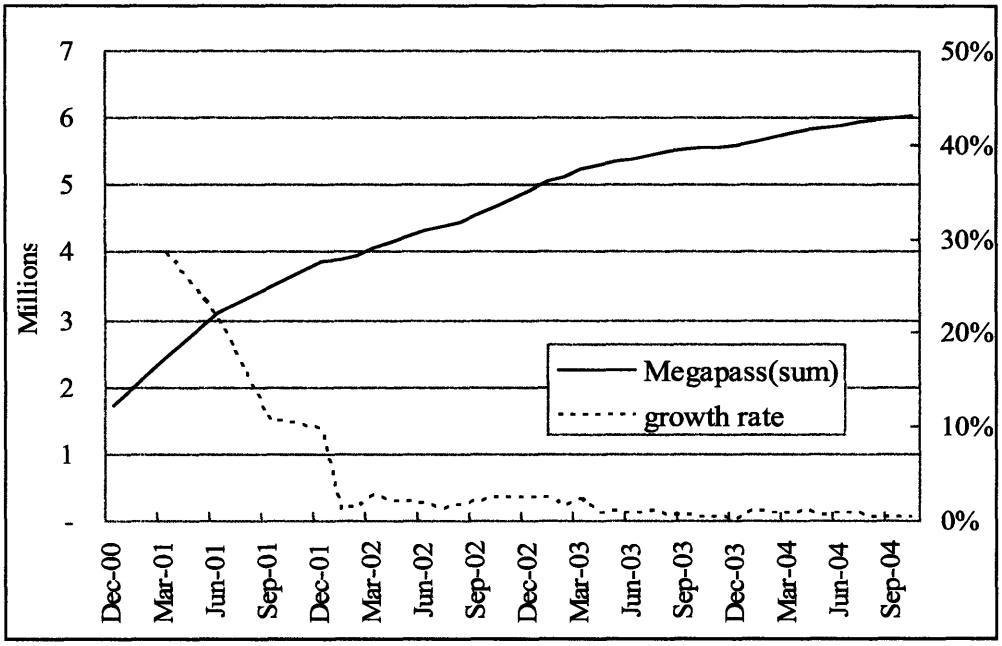


Figure 2.3.2 Number of Subscribers in the Megapass Service



CHAPTER 3 COST OF PROVIDING BROADBAND SERVICE

3.1 Review of ISP Cost Models

Leida's ISP cost model [LEI98] divided internet services into 4 types based on the way the customer accesses the network and then defined the types of customers depending on the services offered. With respect to the providers, Leida distinguishes two types such as pure Internet provider and IP phone provider. Then, Leida set up two scenarios, base line scenario and Internet telephony scenario. The customer behavior has the direct influence to the generated amount of data traffic which is higher in Internet telephony than in the other scenario. The higher data traffic corresponds to larger requirements in network resources.

There have been several cost models from different perspectives. For the pricing concerns, Stiller et al [SRL01] discuss general factors influencing the choice of a pricing model in practical situations. Through investigating cost models, they address the important price and cost issues from an ISP's point of view. With an emphasis on the business relations of ISPs, Altmann [ALT00] presents a reference model of Internet businesses by defining the basic roles that a business can play on the Internet and displaying the value chain in the ISP market. From the accounting aspects, the model of Reichl et al [RKGS01] is service-oriented costs model that designs three cost categories such as cost types, cost locations, and cost units. The work of Payne et al [PD] is about the mismatch between the cost of providing bandwidth and the consequential growth in revenues. The paper proposes a technical solution by using optical networking technology. M3I's ISP cost model [M3I03] integrates pricing, technology, and market service aspects in cost management. The model carries two main points that a suitable cost model serves the ISP with respect to internal cost management and provides a basis for calculating charges for value added internet services.

3.2 Cost Structure

Varian [VM93] classified the cost of providing the Internet into several components to propose a new pricing mechanism. The largest component of the cost is the fixed cost of providing the network infrastructure which includes the rent for the line, the cost for the routers and servers, and the salary for the support staff. Next, the cost of expanding network capacity is the cost of adding new network infrastructure when network usage reaches capacity and needs expansion. The cost of connecting to the network is the cost for new connection to the Internet that involves costs for installing a modem at one time. The incremental cost of sending extra packets is close to zero if the network is not congested whereas it generates significant social costs if the congestion delays packets on the network.

3.3 Usage Cost and Estimation

Usage cost is the incremental cost that incurs by using the network and the cost can be generated through various ways. For example, the cost of sending an extra packet is one of the usage costs even though it may cost only a little amount of electricity. The significant usage cost in practical sense is not the cost of sending packets by themselves, but rather the usage-sensitive operating cost to repair and maintain the network.

There are intrinsic limitations for researchers outside a firm to examine the cost of the firm. Thus, reasonable assumptions and decisions were made to obtain the reliable calculation of the usage cost. First, to keep the consistency in estimation, all numerical data was based only on the financial statement form 20-F of KT that is annually reported and filed in the U.S. Securities and Exchange Commission[5]. Next, we had to divide the total cost into several subtotal costs for different services since the cost information for broadband service was not separated from the cost for fixed phone, mobile phone, and etc. We assumed that

[5] U.S. Securities and Exchange Commission, <http://sec.gov>

the operating costs for different services are proportional to the operating revenues from the corresponding services. Finally, we assumed that the usage cost is equally paid for the different broadband services.

After examining the cost list, we judged that the components, 'repair and maintenance' and 'utility', are the usage costs directly related to the usage such that the increase in usage directly drives the increase in the cost. To take a part of total operating expenses with revenue weight gives us the final values, 0.9 and 1.0 US dollar per month per subscriber for 2002 and 2003 respectively. The value roughly means that the ISP should charge the subscribers with at least about 1 dollar per month per subscriber for recovering the usage cost. Without any usage information, this cost appears to be negligibly low because monthly one dollar is less than 5% in monthly subscription payment.

Table 3.3.1 Estimated Usage Cost

	2002	2003
repairs and maintenances (millions)	$395	$430
utilities (millions)	$152	$171
usage cost in total services (millions)	$547	$600
revenue in broadband service	9.6%	11.7%
usage cost in broadband (millions)	$52	$70
broadband internet subscribers	4,922,000	5,589,000
usage cost per user per month	$0.89	$1.05

The usage cost may be underestimated for the following reasons. First, KT reported that the company experienced an increase in the repairs and maintenances expense primarily due to the expansion and maintenance of its broadband network. Second, other cost components might be ignored simply because they are not recognizable from the published financial document. Third, the weighted summation relying on the revenue would exaggerate the cost for the fixed phone service because the services are charged depending on the usage.

Also, the usage cost varies over different ISPs, depending on their specific conditions. According to the report on broadband of the McKinsey and JP Morgan Analysis, the usage cost is $5 per month per subscriber for a DSL provider while it is $4 per month per subscriber for a cable provider[6]. Therefore, we need to consider the other values of usage cost. In the chapter 5, we will therefore include different usage cost levels to calculate how much light users spend to indirectly support heavy users through different flat usage fees.

[6] The usage cost is calculated by summing the costs for the maintenance and the network transport in the report.

CHAPTER 4 BROADBAND USAGE

4.1 Description of Broadband Usage

The key points of describing the broadband usage can be summarized in the following questions. What does the distribution of the broadband usage look like? Is the distribution of the data usage different from the distribution of the usage time? How do the distributions change over time? What percentage of people use the network heavily? Do heavy users tend to increase or decrease their usage with time? Are the heavy users constantly heavy over time?

Fortunately, we were able to obtain sample data relevant to analyzing broadband usage from KT. The data was collected by measuring the broadband traffic of VDSL subscribers in Korea. Not all of the questions above can be answered in detail with the current network usage data from KT. For example, the data that we have cannot tell us whether the heavy users stay constantly as heavy users over time since the identity information of the users was eliminated before we obtained the data. Also, it is impossible to find out the mathematically detailed distribution because the data was processed for other purposes. However, the data is still meaningful when we try to look at the shapes and trends of the usage distribution in a commercial network. The usage distribution enables us to calculate the cross-user subsidy.

4.2 Usage Distribution

The usage distributions in terms of data usage were obtained in two cases of Lite and Premium services. The cumulative distribution of data usage (gigabytes per month) is seen on Figure 4.2.1. The figure shows that most of users are using the network less than 10 GB/Month and that about 50% of users are generating less than about 3 GB/Month.

Figure 4.2.1 Cumulative Distribution of Usage in May 2002

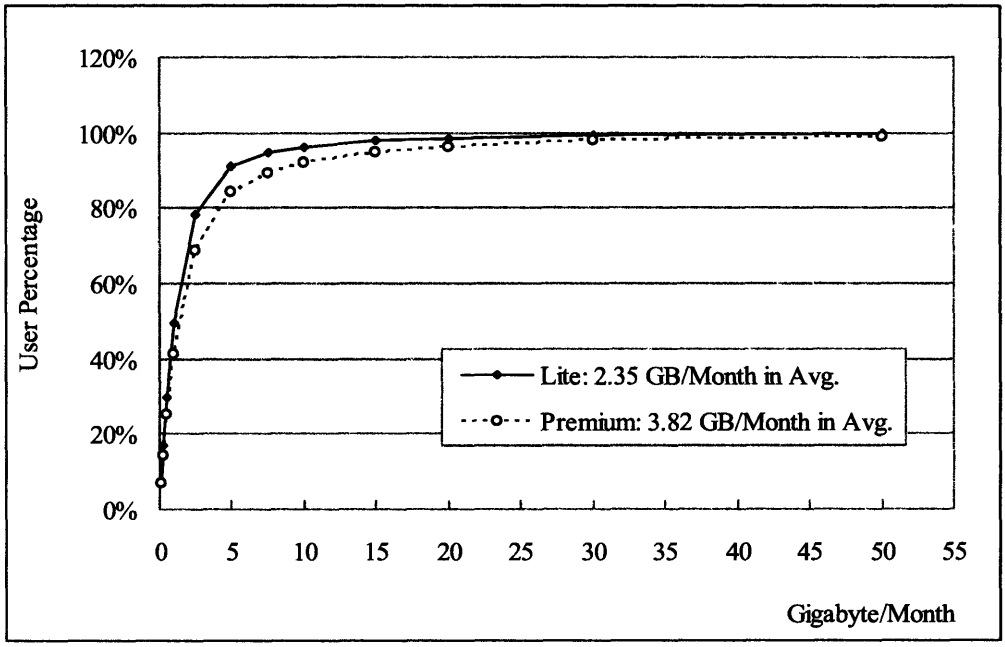
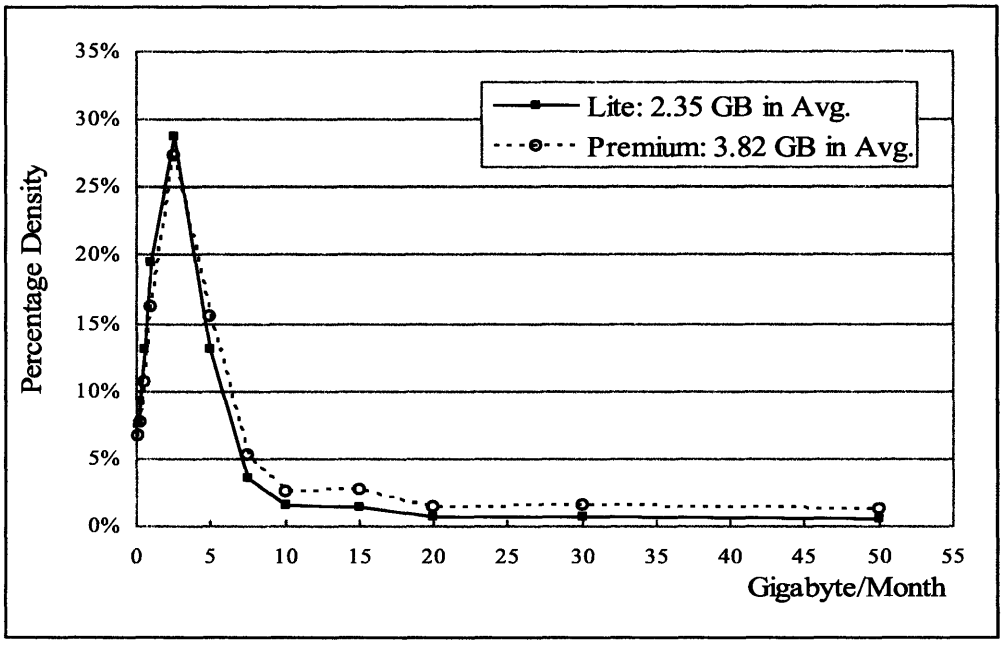
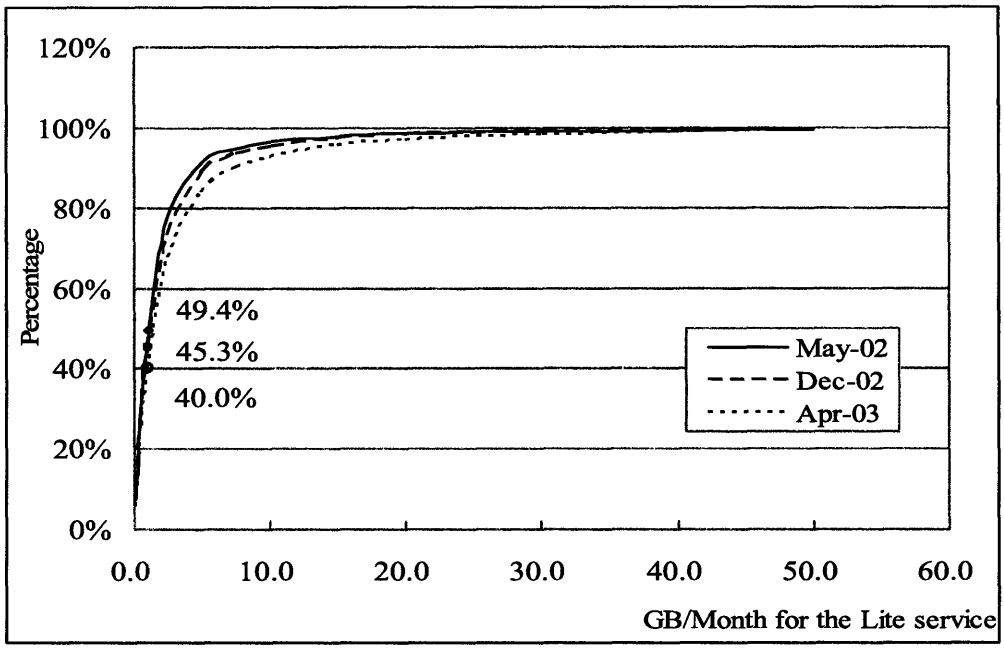


Figure 4.2.2 Distribution of Usage in May 2002



Also calculated from the data set, the density of the distribution in Figure 4.2.2 shows that most of the usage in highly skewed toward below 10 GB/Month[7]. The figure also shows the distribution of the Premium service has heavier tail than one of the Lite service. In other words, the right tail of the distribution does not drop quickly but rather stays almost constant above 20 GB per month. As time passes the distribution of usage also shifts toward the overall heavier usage as shown in Figure 4.2.3. For example, the percentage of users that generated the traffic above 1 GB per month in average increased from about 50% to 60%.

Figure 4.2.3 Cumulative Distribution of Usage over Time



[7] Only the displayed data points have the mass of the distribution in the figure.

The distributions over the usage time are also obtained in Figure 4.2.4 and in Figure 4.2.5 for the light and the premium services. The usage time is measured as time duration of connection to the Internet for any purposes without regarding the amount of data transfer. It is seen that the distribution is more evenly distributed over hour per day and that the subscribers of the Premium service are using the network longer than the subscribers of the Lite service. The average usage times are 3.8 hours per day for the Lite service and 5.5 hours per day for the Premium service. We can see that the distributions are shifting toward longer usage as time goes in Figure 4.2.6. For example, 51.4% of subscribers in May 2002 were using the network for less than three hours a day and the smaller percentage of users in April 2003 remains for less than three hours a day.

Figure 4.2.4 Cumulative Distribution of Usage Time in May 2002

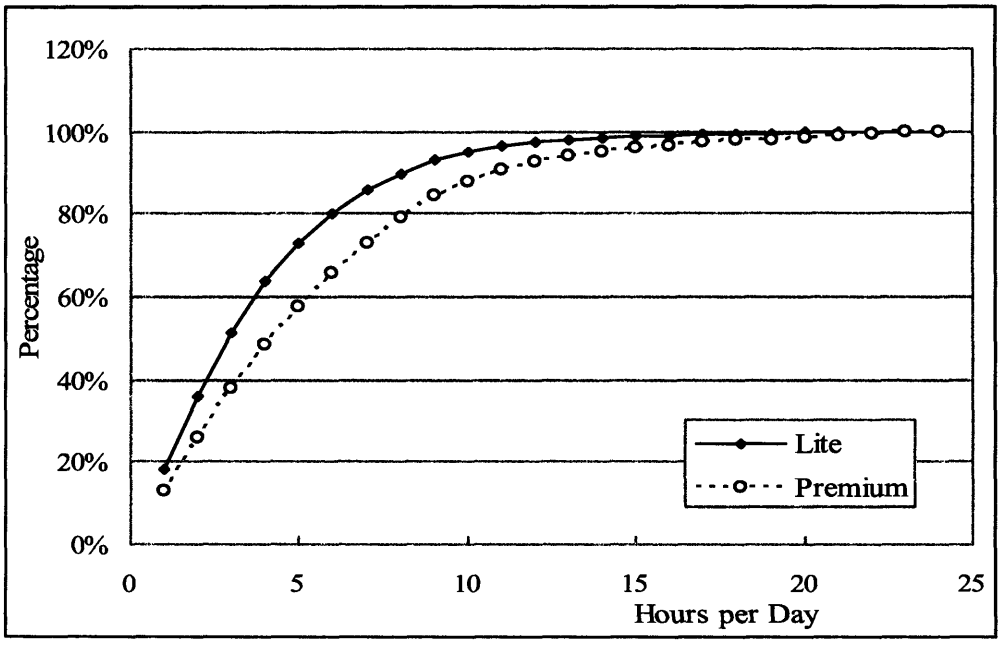


Figure 4.2.5 Distribution of Usage Time in May 2002

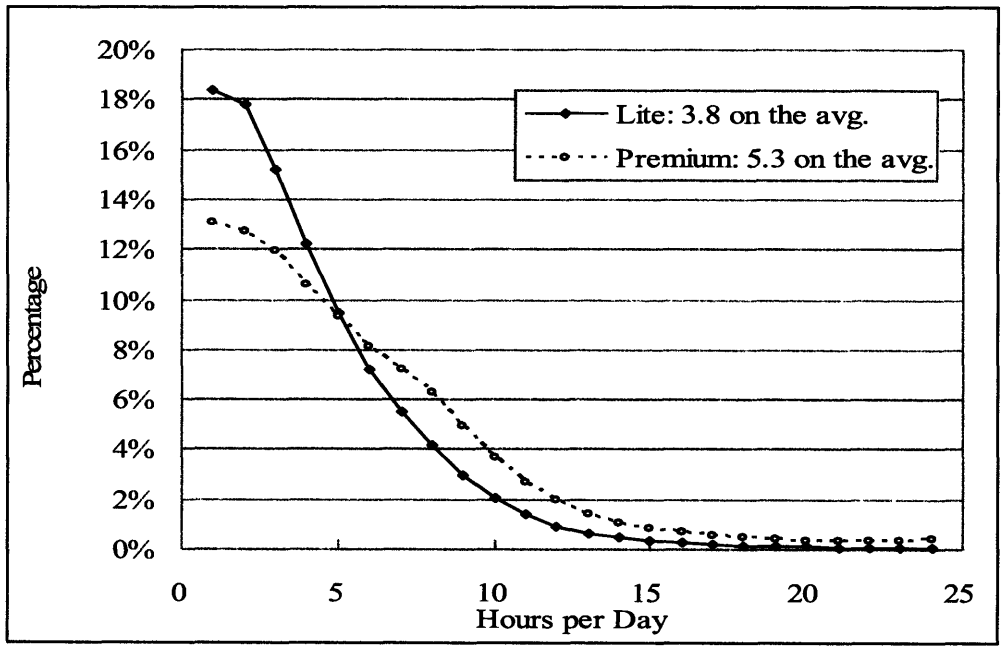
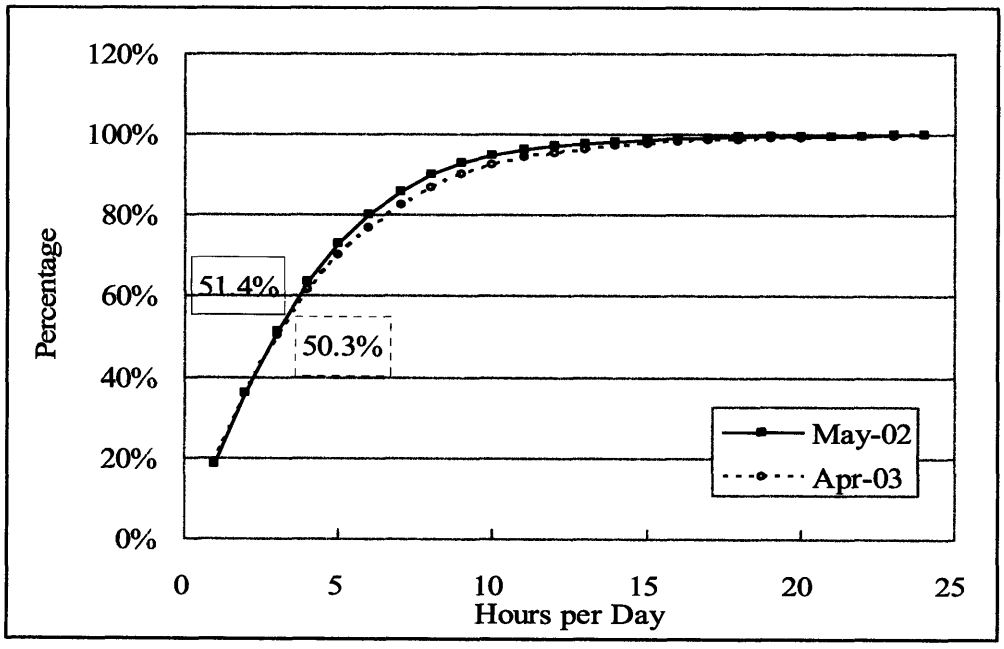


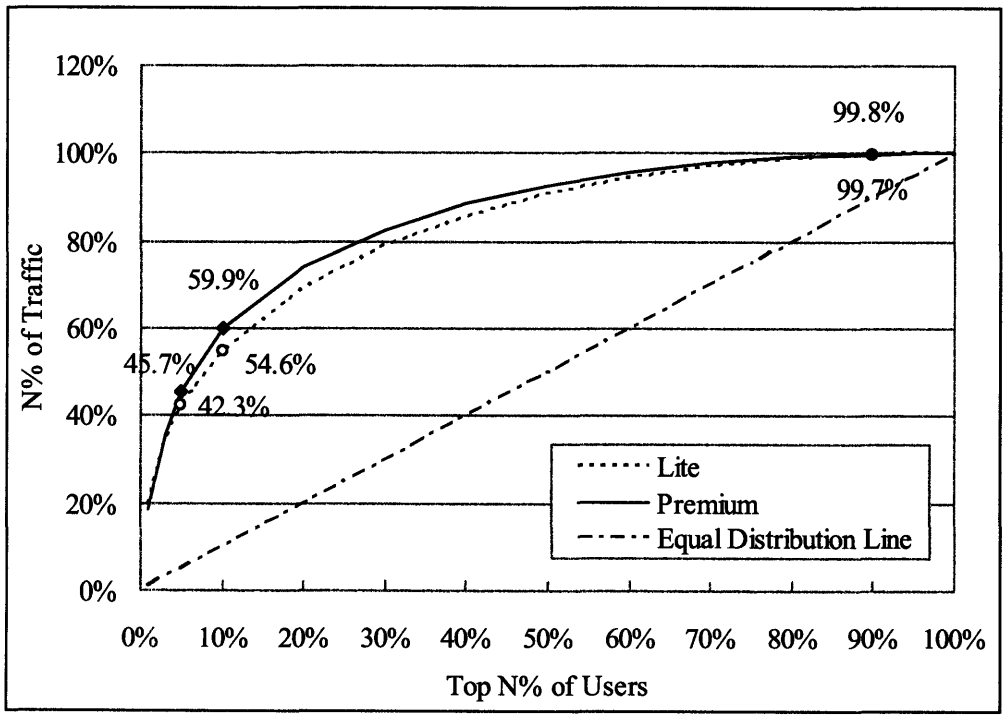
Figure 4.2.5 Distribution of Usage Time over Time



4.3 Heavy Users

There are no formal definitions of heavy users. However, we classify the top 10% of users as heavy users because it is turned out that the top 10% of users are generating more than half the total traffic. In Figure 4.3.1, the top 10% of users are taking more than 50% of the network in both services while the bottom 70% of users are generating less than 20% of the traffic. In the figure, the equal distribution line gives us a clue of fair distribution in the sense that the usage distribution has better fairness if the curve is closer to the equal distribution line. Equal distribution is "fair" because the usage distribution is proportional to the payment of each user. In the following figure, the distribution of the Lite service is better than the Premium service in terms of fairness.

Figure 4.3.1 Usage Distribution over Users in May 2002



We need to look at the usage distribution of heavy users in more detail since the distribution curve grows steeply around the top 10% of users. It is observed that the percentage of heavy users' traffic in total usage did not increase in Figure 4.3.2 whereas the data usage of heavy users has become heavier over time in Figure 4.3.3. Figure 4.3.2 shows an interesting point: the percentage of traffic the heavy users have been taking over time. For example, the top 1% of users have been taking about 20% of the traffic while the whole top 10% groups have been taking traffic more than 50% of total. Moreover, in Figure 4.3.3, we can see that the top 1% of users have been generating about 20 times the traffic of average users in terms of GB/Month. The top 1% of users also take over half the traffic that the top 10% of users takes in Figure 4.3.3.

Figure 4.3.2 Usage Distribution of Heavy Users over Time in the Lite Service

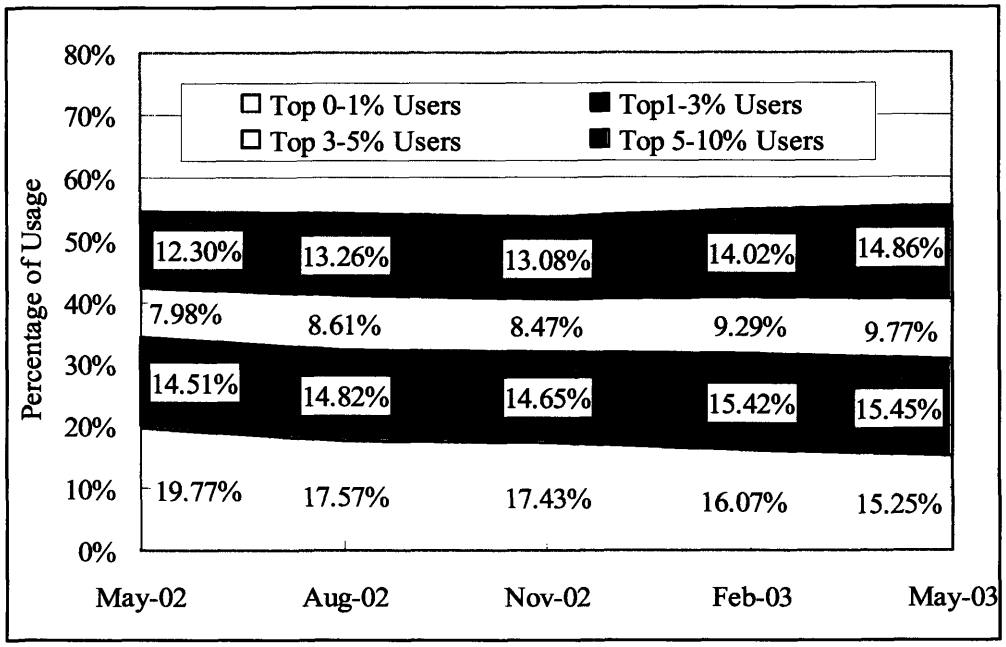
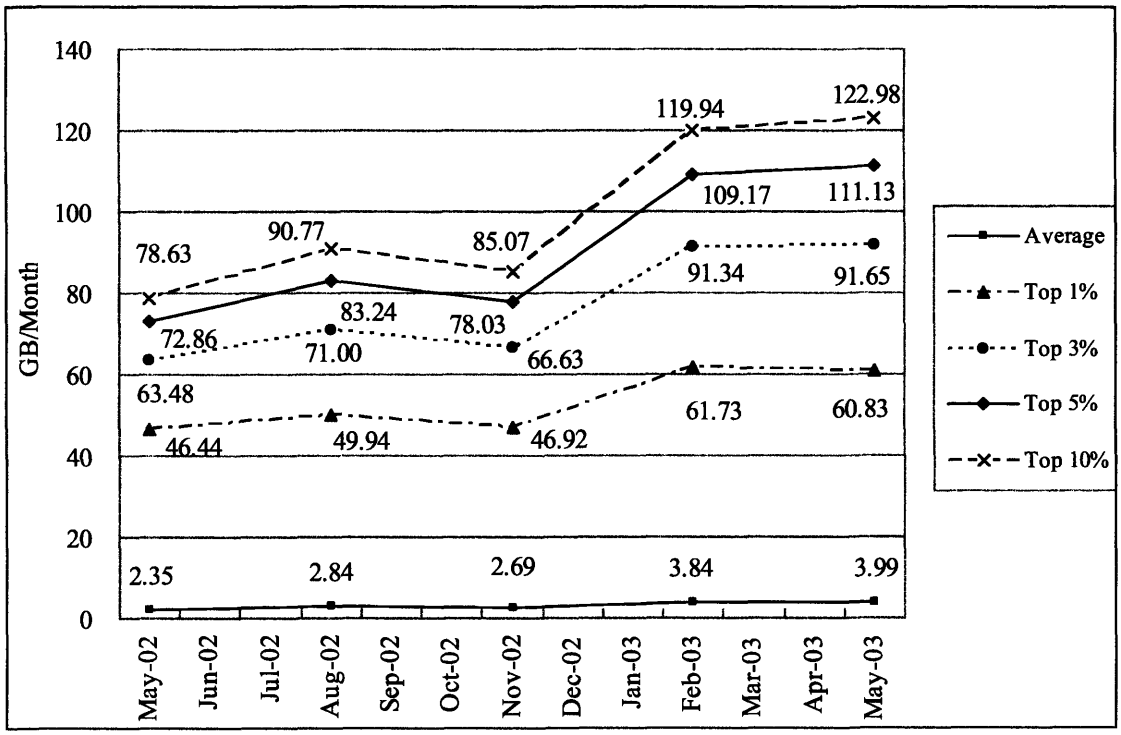


Figure 4.3.3 Usage of Heavy Users over Time in the Lite Service



CHAPTER 5 USAGE and COST

5.1 Cross-User Subsidy

The distribution of the usage in the previous chapter appears to be unfair in that the top 10% of users are generating more than half the network traffic while all subscribers are paying the same usage fee. As a matter of fact, the current flat pricing without recovering the usage cost drives the light users to subsidize the heavy users. The usage fee of serving users is equally spread over all the users whereas the usage cost that each user is generating is proportional to the usage of the user. We take only the usage fee into account instead of the broadband subscription price including the fixed cost. Consequently, we do not consider the profit of the ISP from the usage fee.

Based on the usage distribution and the usage cost estimated in the previous two chapters, the cross-user subsidy can be estimated. Suppose that we have N number of users and the usage data of the users, X_i. The usage cost of an ISP is charged on subscribers with the equal usage fee, C_P. We can calculate the gap between the flat usage fee and the usage cost over the users. The gap is the benefit of heavy users or the overpayment of light users depending on their usage.

$$i = 1, \ldots, N \tag{5.1}$$

$$X_i = \text{Usage of User } i \text{ (GB/Month)} \tag{5.2}$$

$$C_P = \text{Usage Fee (\$/User/Month)} \tag{5.3}$$

$$C_i = \text{Usage Cost generated by User } i \text{ (\$/User/Month)} \tag{5.4}$$

$$Q = \sum_i X_i \tag{5.5}$$

$$C_i = X_i \cdot \frac{N \cdot C_P}{Q} \tag{5.6}$$

$$Gap_i = C_P - C_i \tag{5.7}$$

$$r = \frac{N \cdot C_P}{Q} \tag{5.8}$$

Figure 5.1.1 Cross-User Subsidy

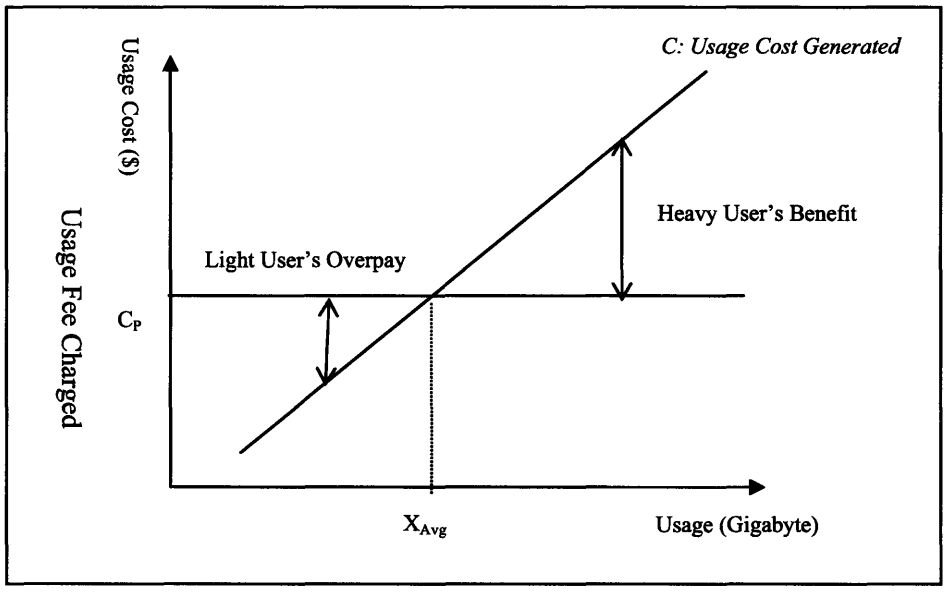


Figure 5.1.1 graphically explains how light users are subsidizing the heavy users. C_P is the usage fee equally charged through the monthly flat price and C_i is the usage cost actually generated by a user. Then, $C_P - C_i$ is the gap between the usage cost paid and the usage cost generated. The positive gap represents the light usage region where the user is paying the usage fee more than the corresponding usage and where the ISP is operating at a profit

level. If the gap is negative, the user is paying less than the actual usage and the ISP is losing money at this region.

From subscriber's viewpoint, the gap is the transferred subsidy from the overpaying of the light users to the benefit of the heavy users. If the amount of the subsidy is tolerably small to be ignored, then the subsidy effect itself may not be important. If a large number of the light users are subsidizing a few heavy users, then the subsidy effect is not negligible from the perspective of fairness.

5.2 Estimation of Cross-User Subsidy

If we categorize users by 10 percentiles, then we can estimate the gap between the charged usage cost and the generated usage cost of one user who belongs to each percentile. Since we assumed there is no profit from charging the usage fee on the users, the gap, Gap_i, is zero for the average users.

Figure 5.2.1 Cross-User Subsidy per User for the Lite Service in May 2002

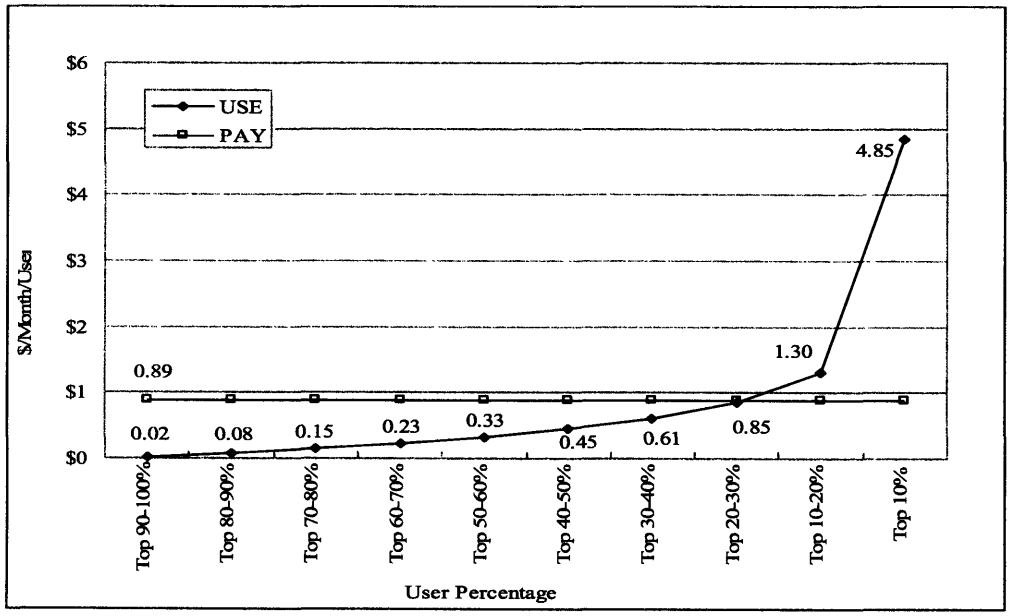
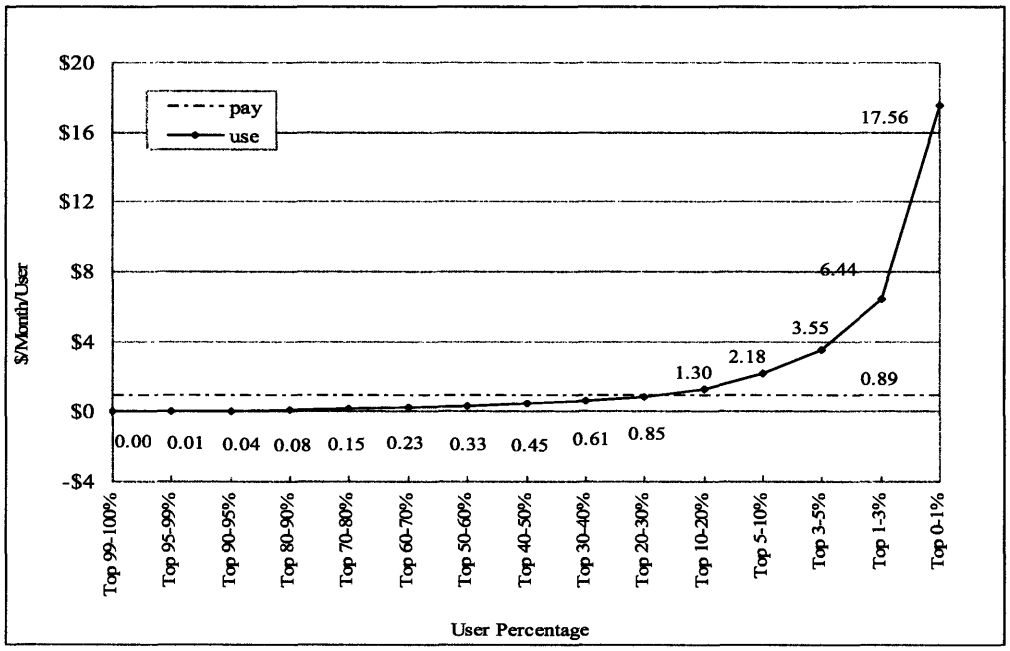


Figure 5.2.1 shows the estimated cross-user subsidy per user in each group for May 2002. Approximately, the bottom 80% of users are supporting the top 20% of users by overpaying the usage fee. For example, a user in the bottom 10% spent $0.87 in excess of their cost of $0.02 in May 2002 to support one of heavy users in the top 20%. To support one user in the top 10%, more than four users in the bottom 10% are needed. The situation appears to be worse when we investigate the subsidy for heavy users in detail as shown in Figure 5.2.2. For example, about nineteen users in the 1st percentile usage are needed to subsidize a user in 99th percentile.

Figure 5.2.2 Cross-User Subsidy of Heavy Users for the Lite Service in May 2002



5.3 Cross-User Subsidy over Time

Since the simple summation of the cross-user subsidy gives us just zero, we need to use another metric to figure out how the cross-user subsidy effect changes over time. If we define a usage ratio to be the ratio of the usage of the top 20% to the usage of the bottom

80% since the top 20% of users are benefiting from the subsidy effect. Table 5.3.1 shows that the usage ratio of the top 20% to the bottom 80% users increases very slowly over time in the Lite service. The cross-user subsidy effect is not likely to be improved under the flat usage fee.

$$\text{Usage Cost Ratio} = \frac{X_{Top20\%}}{X_{Bottom80\%}} \tag{5.8}$$

Table 5.3.1 Usage Ratio for Top 20% and Bottom 80% users

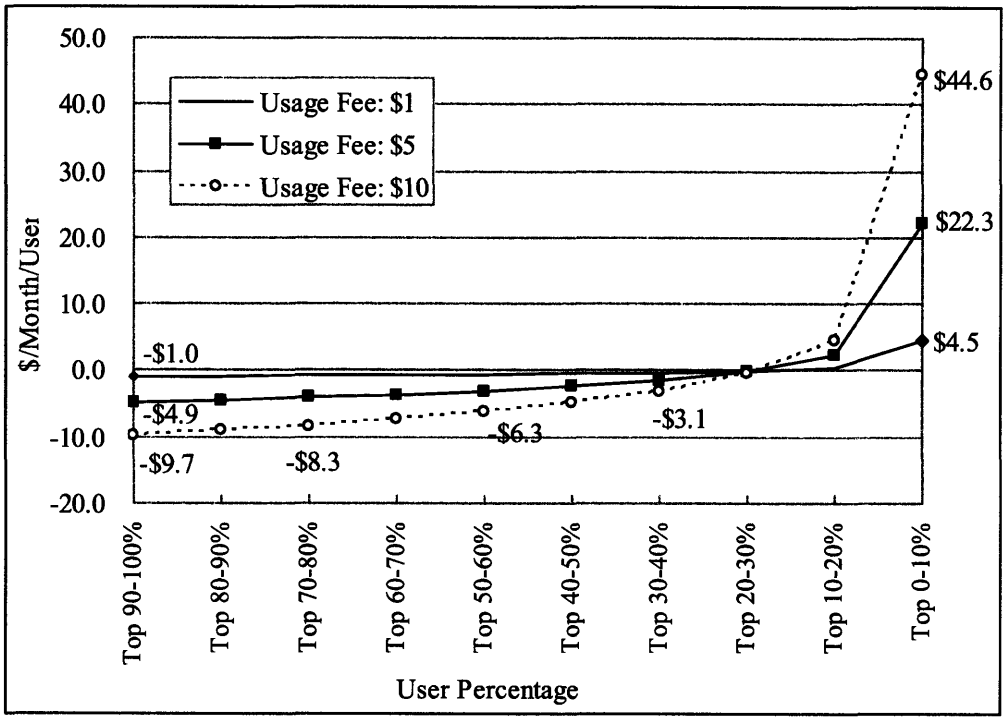
	May-02	Aug-02	Nov-02	Feb-03	Apr-03
Usage Ratio	2.25	2.28	2.22	2.38	2.44

5.4 Cross-User Subsidy with Variable Usage Cost

The usage cost is the main factor that changes the cross-user subsidy. Even though the usage cost was estimated for one dollar, the usage cost may vary depending on ISP's size and technology. From a user's perspective, a 10 dollar overpayment would not be tolerated by light users but a one dollar overpayment may be endurable. Therefore, we need to look at how the cross-user subsidy varies depending on different usage costs.

Figure 5.4.1 shows the cross-user subsidies with \$1, \$5, and \$10 usage costs. The underlying assumption is that an ISP with monthly \$10 usage cost per user is equally charging the subscribers with \$10 usage fees with no profit. In the \$10 usage cost case, the subsidy appears to be intolerably high for light users. The subsidy is distributed over the light users (80% of total) and varies from \$0.41 for the top 20-30% users to \$9.7 for the top 90-100% users. One user in the top 10% benefits by \$44.6 whereas one of the bottom 10% overpays \$9.7.

Figure 5.4.1 Cross-User Subsidy with Varying Usage Cost



5.5 Implications

Suppose that an ISP with a $10 usage cost tries to offer a new service that excludes the upper 20% users who take over about 70% of the network traffic. For example, a competitor might enter the market and try to attract all the small users by creating a product that excludes the top 20% of heavy users. We assume that the usage cost, dollar per gigabyte, stays the same and that the user behavior also stays constant. Then, we can simply think that the ISP should be able to lower the usage fee down to about 38% (=3/8) of the original usage fee, for instance, $3.8 while keeping profits at the same level. Table 5.5.1 shows the various usage fees and the corresponding usage fees without the heavy users necessary to maintain the same level of profits for the ISP.

Figure 5.5.1 New Usage Fee without Heavy Users

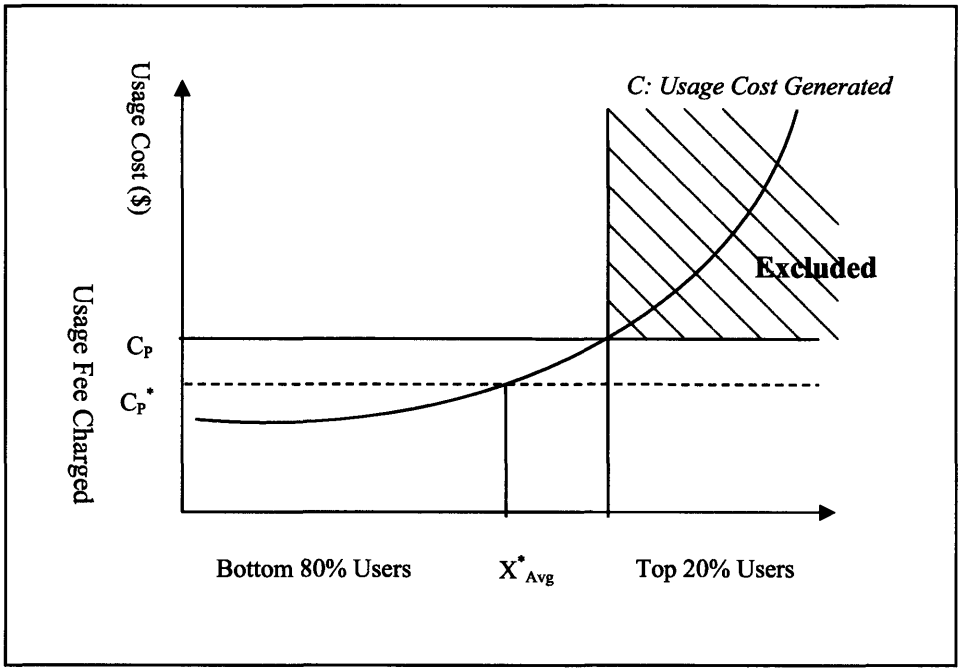
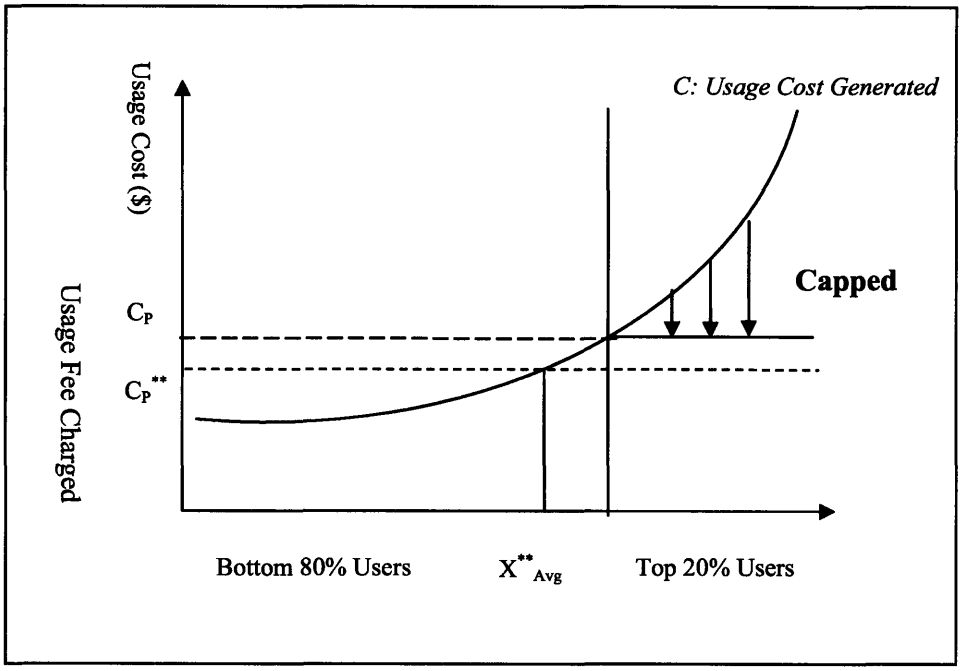


Table 5.5.1 New Usage Fee over Various Usage Costs

Usage Fee	$1	$3	$5	$10
Usage Fee without Heavy Users	$0.39	$1.16	$1.93	$3.85

Also, suppose that an ISP with a $10 usage cost tries to offer a new service that cap the usage of the upper 20% users so that the heavy usage stays at the corresponding usage level of the original usage fee. Under the same assumption with the previous example, the ISP should be able to lower the usage fee down to about 50% of the original usage fee while keeping profits at the same level.

Figure 5.5.2 New Usage Fee with Cap on Heavy Usage



CHAPTER 6 CONCLUSION

Throughout the thesis, we tried to answer the question: how much are light users spending to support the heavy users under flat pricing? First, we investigated the cost structure in providing broadband service. The usage cost is estimated based on the published financial document of an ISP. The usage cost is calculated by the weighted sum of the usage-sensitive cost components in the operating expenses. The calculation suggests that the ISP equally charges the subscribers at least one dollar in the flat subscription fee to recover the usage cost. In other words, $1 out of the total monthly subscription fee is for the usage.

Then, we analyzed the monthly broadband usage in terms of the data amount and the time duration. The cumulative distribution of the data usage tells us that the top 10% of users are taking 50% of the network traffic and that the top 1% of users are taking 20% of the network traffic. Also, the distribution is shifting toward heavier usage over time. More interestingly, the heavy users (the top 10%) are increasing the average usage while the percentage of their usage to the total usage is decreasing due to the increase in the total usage. The distribution of the usage time (hours per day) has a smoother shape than distribution of the data usage (gigabytes per month).

Finally, we estimated the cross-user subsidy between heavy users and light users under the flat usage fee. Based on the usage distribution in chapter 4 and the usage cost of chapter 3, the cross-user subsidy only for the usage cost is estimated without regarding the profit of an ISP. The flat usage fee results in a cross-user subsidy effect that the top 20% of users are subsidized by the bottom 80% of users. More than four users in the bottom 10% are subsidizing one user in the top 10%. The subsidy effect does not diminish as time goes by. The heavy users (the top 20%) continue to benefit from the light users (the bottom 80%) with the presence of the cross-user subsidy under the flat usage fee. In conclusion, the light users can get the significant discount on the usage fee if the provider excluded the heavy users or used a cap on the heavy usage.

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