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Empirical Analysis of Internet Service Provider and Its Policy Implications[*]

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—ABSTRACT —

The Internet Service Provider (ISP) supporting the Internet has grown rapidly in recent years. In this paper, we analyze the management performance on ISPs quantitatively and qualitatively, compensating the lack of public data with questionnaires and interviews. First of all, we find the difference between nationwide and local providers by the statistical methods. Next, we consider the services for nationwide and local providers to put much emphasis on - content services and community-friendly services -. Finally, we study information security issues which every provider faces. We suggest several policy implications on ISPs.

Key words: *Internet Service Provider (ISP), empirical analysis, policy implication, CDN (Content Distribution Network), community-friendly strategy, information security, spam mail, DEA (Data Envelopment Analysis), correlation analysis, optimization model*

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1 Introduction

ISPs which provide the connection between users and the Internet, that is one of the social infrastructures, have grown rapidly these ten years. The main business of ISPs is to enable users to access the Internet through a communication line. Nowadays, most of ISPs give various additional services, for example, a content service, a hosting service, creation of web pages, system integration, and so on. However, there is little research on ISPs, for lack of public data.

In this paper, we take up ISP and try to analyze ISP empirically. We conducted 3 questionnaires and made interviews to 5 nationwide providers and 13 local providers, in order to make up for lack of Information. The interviews show that the goals of ISPs are very various. The nationwide providers say that as they cannot gain enough profits only by connection fees, they direct the management power towards a wide variety of additional services. On the other hand, the local providers say that as they cannot invest in additional services sufficiently due to a shortage of capital investment, they direct the management power towards community-friendly services. What is the difference between nationwide and local providers? Is the management efficiency of local providers satisfactory? Are local providers in the fate screened?

In section 2, we make clear that the differences in the management efficiency between nationwide and local providers from the analysis of the data derived from our first questionnaire survey by DEA (Data Envelopment Analysis). Next, in order to clarify the difference in the management strategy between nationwide and local providers, we consider the services for nationwide and local providers to put most emphasis on. First, for nationwide providers, we propose a tool for content service providers in section 3. We examine the optimal design of CDNs (Content Distribution Networks) using an example of a nationwide content service provider in Japan. Here, we introduce our CDN optimization model considering trade-offs between the cost, the reliability, and the delay. Second, for local providers, we show useful community-friendly strategies from the results of our third questionnaire survey, in order to improve local provider's management performance in section 4. Last, we consider some serious problems faced on both nationwide and local providers. In section 5, we study information security issues, which every provider faces. We suggest some implications analyzing the results of our second questionnaire survey. Finally, we discuss the spam mail problem, one of the important information security issues. We estimate the economic losses by spam mail and advice the countermeasures against spam mail.

2 How Degree Is the Difference between Nationwide and Local Providers?: Efficiency Study Using DEA

ISPs in the local areas have created advanced information societies and promoted local communities. Recently, while nationwide providers are expanding their service coverage, local providers are facing their operational difficulty.

Are there any differences in the management efficiency between nationwide and local providers? We conduct the efficiency study of the selected ISPs using DEA. Then by using the Mann-Whitney's rank sum test, we examine whether nationwide and local providers have a statistical difference in the efficiency scores calculated by DEA.

2.1 Data and samples

Our dataset has two inputs and three outputs; that is the number of staffs (adjusted by outsourcing ratio) and ICT (information and communication technology) asset[1] as inputs, total revenue, the number of corporation customers and the number of personal customers as outputs. We adopt input orientated VRS (variable returns to scale) as DEA model. The number of samples is 30. All data are derived from our first questionnaire survey in July 2004[2].

Descriptive statistics of our data is as follows.

Table 1. Descriptive Statistics

	Mean	Standard deviation	Min	Max
Number of staffs	130	483	1	2,635
ICT asset(thousands)	¥4,051,767	¥15,380,738	¥144	¥79,705,750
Total revenue(thousands)	¥7,556,307	¥28,975,599	¥42	¥146,400,000
Number of corporation customers	25,756	136,803	0	750,000
Number of personal customers	166,427	774,802	0	4,250,000

2.2 DEA Results

Figure 1 shows DEA results[3]. All samples are divided into two groups. One is the nationwide and metropolitan providers (local providers located in three metropolitan cities; Tokyo, Aichi, and Osaka), and the other is the local providers (local providers excluding the metropolitan providers).

1 ICT asset corresponds with the amount of capital investment (except items on lease) adjusted by depreciation ratio from 2000 to 2002 fiscal year.
2 See Ebara, Nakaniwa, Takemura and Yokomi (2006) in detail.
3 About the DEA method, see Cooper, Seiford and Tone (2000) in detail.

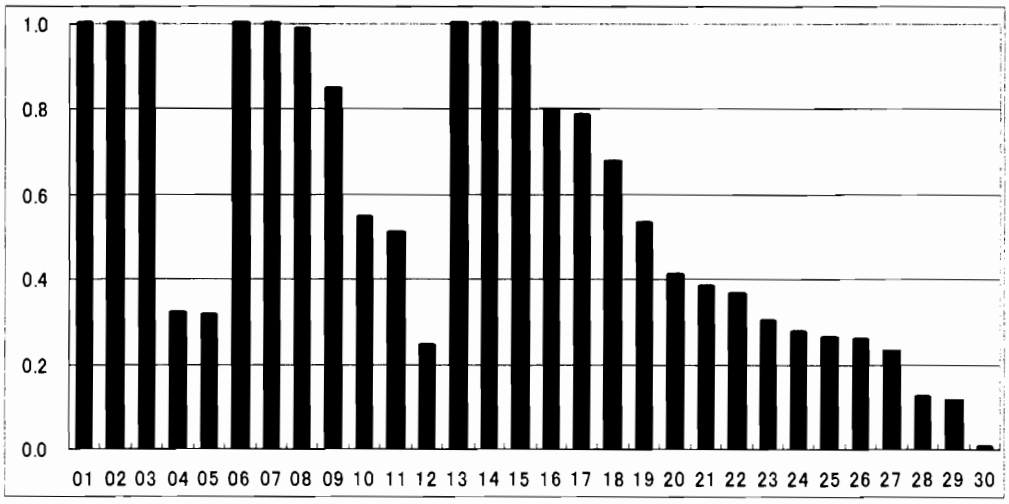

Figure 1. DEA Scores

The vertical axis corresponds to the efficiency score and the horizontal axis means each sample number. Sample numbers 01 to 05 are the nationwide providers, 06 to 12 are the metropolitan providers, and 13 to 30 are the local providers. The sample achieved 1.0 score means the best performer.

Note that the sample number 13 and 15 are the NPO (non profit organization) entities. Both of them achieve 1.0 score (most efficient). Generally speaking on NPO sectors, most of their staffs are volunteers, so their staff cost is relatively low.

2.3 Statistical Difference

Next, employing the DEA score calculated above, we examine the statistical difference between the nationwide and metropolitan providers, and the local providers by using the Mann-Whitney's rank sum test.

We show the results in Table 2 and 3. Table 3 excludes 2 NPO entities from the samples.

These results show that there is 5% significance (including NPO) or almost 1 % significance (excluding NPO) between these two groups. Therefore we can find the statistical difference in the efficiency scores between the nationwide and metropolitan providers, and the local providers. This means the local providers are less efficient than the nationwide and metropolitan providers.

Table 2. Result of Mann-Whitney's Rank Sum Test

(Including 2 NPO Entities)

	Nationwide and metropolitan providers	Local providers
Number of samples	12	18
U-statistic		60.5
Expectation		108
Variance		547.5724
Z-statistic		2.029892
p-value		0.0423676

Table 3. Result of Mann-Whitney's Rank Sum Test

(Excluding 2 NPO Entities)

	Nationwide and metropolitan providers	Local providers
Number of samples	12	16
U-statistic		41.5
Expectation		96
Variance		459.5556
Z-statistic		2.542304
p-value		0.0110124

2.4 Implications

In this section, we conduct the efficiency study of 30 ISPs by DEA. All samples are categorized into two groups, one is the nationwide and metropolitan providers, and the other is the local providers. Employing the DEA scores, we examine the statistical difference in the efficiency score between the two groups by using the Mann-Whitney's rank sum test. As a result, we can find that the local providers are less efficient than the nationwide and metropolitan providers.

As we adopt the input orientated DEA model, these results mean that the local providers need to use their human resources and their ICT assets more efficiently. However, most of the local providers are operated with relative small number of staffs, therefore we assume that the reduction on the ICT assets leads to the improvement of their management efficiency.

The difference in the management efficiency between nationwide and local providers became clear from our DEA analysis. We study the services for nationwide and local providers

to put much emphasis on in Section 3 and 4. First, we introduce a tool of the content service to use the ICT assets efficiently in the next section.

3 Management Strategy for Nationwide ISP "BBit-Japan": Optimal Network Design on Content Services

CDNs have been spread rapidly as the network bandwidth and the variety of content have grown. The content service is one of the most popular web services that ISPs provide, since most of nationwide providers are currently challenging to provide additional services besides their original service of providing the access to the Internet.

In the Internet, there has been an explosive increase in the number of users. This causes network servers to become overloaded, and we are faced with several serious issues, such as the decline of the reliability, the increase of the response time, and so on. The replicated allocation of content files on cache servers for the load-balancing is known as the effective solution to overcome these issues. In CDNs, it is one of the most important problems how we allocate cache servers and content files while considering trade-offs between the cost, the reliability, and the delay.

In this section, in order to investigate this problem, we examine an example of the content service in an ISP "BBit-Japan", which is one of the biggest content service providers in Japan.

3.1 CDN System of BBit-Japan

We show the CDN system of BBit-Japan in Figure 2. This system has 1 file server with 2.5TB HDD and 11 cache servers with 250GB HDD. They hold approximately 4300 kinds of content files. The size of each content file is 1MB to 2GB. They place the central file server and the administrative use of web server in the CDN center, and place the cache servers in 7 local areas in Japan. Users in each local area first access the administrative web server through the Internet, and request the delivery of a content file. If the requested content file exists in the cache server of the user local area, the cache server delivers the content file to the user. Otherwise, the central file server delivers the content file to the user. In the latter case, the content file is stored in the cache server of the local area. The content file which is least requested is automatically removed from the cache server.

In the CDN system of BBit-Japan, the mirroring of the file servers and the cache servers has not been carried out except a part of the central file server. However, the number of CDN users is expected to explosively increase because of the diffusion of FTTH and the diversification of content files. Therefore, it is very effective method for the improvement of the

reliability and the response time to achieve the load-balancing by the mirroring of servers and replicated allocation of content files.

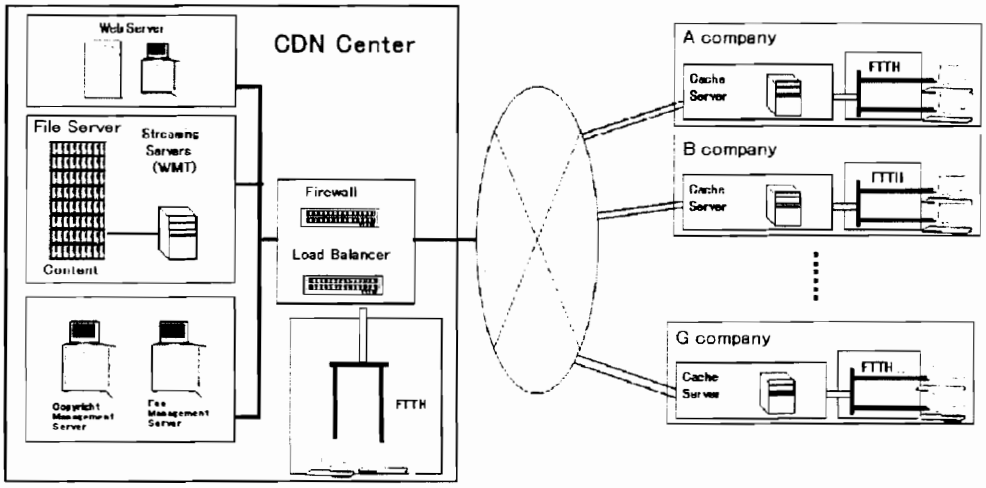

Figure 2. CDN System of BBit-Japan

3.2 Optimal Network Design on CDN

We apply this example to the cache server and content allocation model which we have proposed in Nakaniwa, Takahashi, Ebara and Okada (2000) and Nakaniwa, Takahashi, Ebara and Okada (2002). This optimization model introduces 0-1 integer programming to determine the optimal allocation of cache servers and content files. In this optimization model, we aim to maximize the reliability of the whole system subject to the restriction of the cost and the delay, in considering the trade-offs between the reliability, the delay, and the cost.

Figure 3 shows the reliability characteristics on the cost restriction ¥85 million to ¥160 million with 11 cache servers. As you can see, the less the cost becomes, the more the reliability falls. Whenever the cost increases ¥25 million, the reliability improves about 0.007%.

Figure 4 shows the number of cache servers on the cost restriction ¥85 million to ¥160 million. In order to raise the reliability, it is desirable to set up many cache servers as long as the cost allows. If the number of cache servers is extended to 24, the reliability improves about 0.08%.

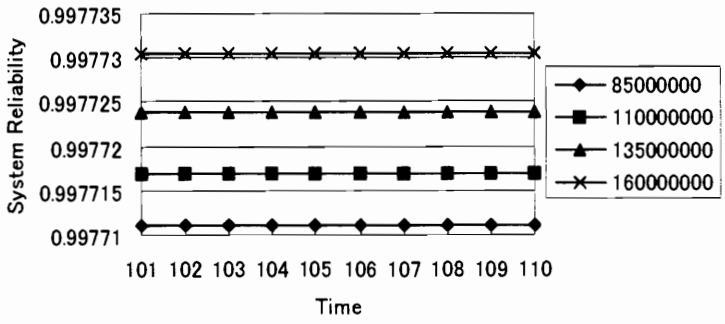

Figure 3. Reliability Characteristics on Cost Restriction

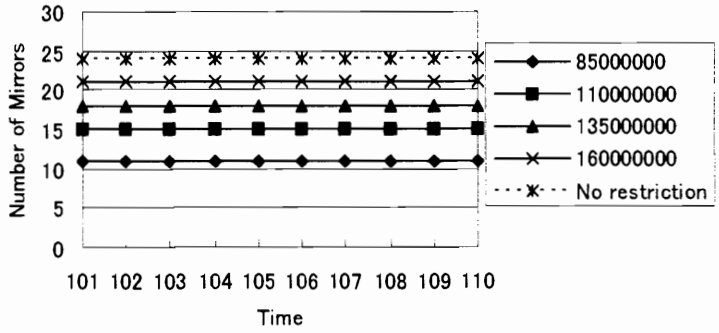

Figure 4. Number of Cache Servers on Cost Restriction

3.3 Implications

We propose a tool to design an optimal CDN for content service providers. By using this optimization tool, it becomes possible to show exactly how they can properly allocate cache servers and content files for the limited cost and the allowable delay to the content service providers. We can conclude that this tool is useful for all content service providers.

4 Management Strategy for Local ISP "Shirakami Net": Qualitative Analysis on the Community-Friendly Strategies

Community-friendly strategies are very important for local providers to improve the management performance or not to be screened. The objective in this section is to examine what kind of community-friendly strategies improve the local providers' management performance. Community-friendly strategies mean the strategies which promote the convenience of the local

residents, for example, free technical support, low-priced classes in PC skills, and websites for the local community.

This study is based on our third questionnaire survey for Shirakami Net, a local provider in Akita Prefecture, Japan. Traditionally, Shirakami Net gives high priority to its community-friendly strategies. We show the useful community-friendly strategies for Shirakami Net.

4.1 What is Shirakami Net?

Shirakami Net is a local provider and operates as a NPO (non profit organization) entity. Its service area is Noshiro-Yamamoto region, north part of Akita Prefecture, Japan. Most part of the region is agricultural district and the ratio of the Senior citizen is relative high.

Recently some nationwide providers expand their service area to the local region served by Shirakami Net. Then to compete these providers and to survive itself, Shirakami Net promotes their original service, that is community-friendly strategies.

4.2 Summary of Our Questionnaire Survey

We conducted questionnaire survey to all users of Shirakami Net in September 2005. We can collect 268 answers out of 1567. The main purpose of our questionnaire is to make clear the user's preference about the community-friendly strategies of Shirakami Net[4].

4.3 An Assumption

Now we make an assumption that the local residents can be divided into two categories concerning the difference of their mind about the local community. We call them Conservative category and Progressive category (Figure 5). The former includes the people who give high priority to the connection inside of their community. On the other hand, the latter includes the people who give high priority to the connection outside of their community.

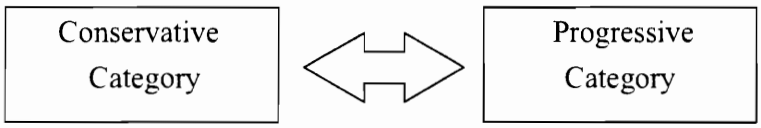

Figure 5. Classification of the Local Residents

4 As for the questionnaire survey, see Ebara, Nakaniwa, Takemura and Yokomi (2006) in detail.

4.4 Local Community Site

In this analysis, we focus on the establishment of local community site as the community-friendly strategies. Local community site is the website, which provides some useful information for local residents, for example the information about the local security or local activities, or BBS exchanging local information, etc.

On the local community site, we suppose that the people in the conservative category mentioned above prefers the content useful for only local residents, for example, the local security or local activities. On the other hand, the people in the progressive category prefer the content useful for the outside residents, for example, the information about tourist attractions.

4.5 Difference between Two Categories

Then we show the difference of the preference between two categories by our questionnaire results. Note that the classification of these two categories is derived from our questionnaire result. Figure 6 shows the percentage about 7 answering items of each category.

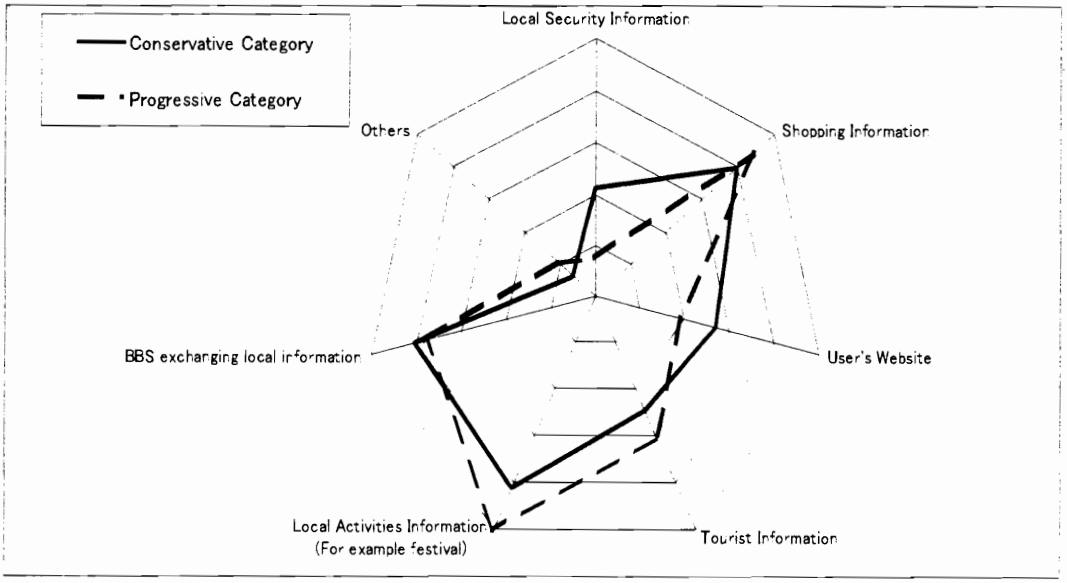

Figure 6. On the Local Community Site, which Content Do You Want?

In this figure, "Local Security Information" and "User's Website" are relative high percentage at the conservative category. By the contrary, "Tourist Information" is relative high at the progressive category.

4.6 Implications

By our simple analysis, we can find the difference of the preference about the content on local community site between two categories. Therefore, as to the community-friendly strategies, a local provider such as Shirakami Net must focus each category respectively. It is significant that suitable services are provided for the users of each category.

5 Some problems faced on ISPs: Relationship between Information Security Countermeasures and Management Performance

By the rapid progress of advanced information society, each firm was able to expand the business opportunity (B2B and/or B2C) through the Internet. On the contrary, the advanced information society yielded undesirable by-products, too. Concretely speaking, it is information security damage such as infection by computer virus, DoS (Denial of Service) attack, defacing, and unauthorized (illegal) access. These are serious social issues for firms and individuals who strongly depend on the Internet.

Recently, one of the matters in ISPs is to establish information security. Yokomi, Ebara, Nakaniwa and Takemura (2004) and Ebara, Nakaniwa, Takemura and Yokomi (2006) show that it is difficult for local providers in Japan to achieve their sales that correspond to the cost in spite of their management effort. Given the fact, we easily guess that many local providers are not able to take enough information security countermeasures that need the huge capital investment.

In this section, we grasp the circumstance of ISP's information security countermeasures by conducting a questionnaire at first. Secondly, we examine the relationship between information security countermeasures and the management performance by correlation analysis. Finally, we suggest the policy for ISPs' information security countermeasures that government should select.

5.1 Summary on Results of the Questionnaire

We conducted a questionnaire about financial information, application service, and need of national support system for information security countermeasures. See Ebara, Nakaniwa, Takemura and Yokomi (2006) about details of our second questionnaire[5].

As a result, we found that many ISPs recognized the importance of the information security countermeasures, but adequate countermeasures were never taken. One of the main reasons is the lack of finance. Therefore, from the viewpoint of cost-benefit, information

[5] Unfortunately, response rate is about 5.1% (the number of ISPs' response to our questionnaire is about thirty), but we try to complement it by making interviews.

security countermeasures takes a backseat to keeping existing service, because information security countermeasures need the huge capital investment. In addition, we found that many local providers necessarily acquired neither enough technology nor knowledge to information security. Moreover, it is clear that there are few support systems to ISPs in Japan[6].

5.2 Correlation Analysis

Here, we examine the relationships between information security countermeasures and management performance by correlation analysis. Then, we use qualitative and quantitative data (items about financial information and application service). Thus, we employ Spearman's rank correlation coefficient, and test some hypotheses by using the coefficients.

Spearman's rank correlation coefficient r_s is derived by the following expressions[7]:

$$r_s = \frac{T_x + T_y - \sum_{i=1}^{n} d_i^2}{2\sqrt{T_x T_y}},$$

$$T_x = \frac{(n^3 - n) - \sum_{j=1}^{n_x} (t_j^3 - t_j)}{12} \quad \text{and} \quad T_y = \frac{(n^3 - n) - \sum_{k=1}^{n_y} (t_k^3 - t_k)}{12},$$

where $d_i\,(i = 1, 2, \cdots, n)$ is the rank deference of samples, n is the number of samples, and n_x and n_y are the number of the same rank for variables X and Y, respectively. In addition t_j and t_k $(j = 1, 2, \cdots, n_x; k = 1, 2, \cdots, n_y)$ are size of the same rank.

Next, we carry out correlation tests used to assess whether there are relationships between some variables. Then, we set up the null hypothesis that population correlation coefficient is zero and the alternative hypothesis that the correlation coefficient is not zero.

In this paper, sales, total asset, payroll number, and revenue received for individual contract are used as indexes which represent the management performance. On the other hand, we use priority of information security countermeasures, implementation of information security education, the number of introduced information security system, and the degree of budget for information security as indexes of information security countermeasures.

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6 The support system has not established to not only information security countermeasures but also general ISP business.

7 Because our samples possess same rank. this expression is employed.

Table 4. Spearman's Rank Correlation Coefficient: Results

	Sales	Total Asset	Payroll Number	Revenue Received for Individual Contract
Priority of Information Security Countermeasures	-0.138	0.016	-0.266	0.113
Implementation of Information Security Education	0.672**	0.764*	0.422*	0.677**
The Number of Introduced Information Security System	0.577*	0.462	0.485*	0.449
Degree of Budget for Information Security	0.242	0.182	0.060	0.283

*: $p<0.05$, **: $p<0.01$

Table 4 shows the results of correlation analysis. As a result, we can find the positive relationship between implementation of information security education and the all management performance at 1% or 5%-significance level. In addition, the number of introduced information security countermeasures has the positive relationship with sales and payroll number at 5%-significance level. In fact, if ISPs carry out the company-wide information security education, and/or introduce the many information security system to strengthen, then they may achieve their high sales, and vice versa.

5.3 Implications

In this section, we show that many ISPs, especially local providers, do not take adequate information security countermeasures and they are lame-ducks. At the same time, we found that the support system for ISPs do not still now established in Japan. In such a situation, we are concerned that the existence of a part of ISPs taking inadequate security countermeasures reduces the level of the information security of not only the information and communication industries but also the whole country. Thus, we suggest that the government should make the policy for ensuring information security and reliability over information and telecommunications.

We should discuss how best to ensure the support system toward information security countermeasures, and ask the government to legislate information security compliance in information-communication infrastructures.

6 Some Problems Faced on ISPs: Estimated Economic Losses by spam Mail

Recently, spam mail[8] (unwanted mail) is recognized as a serious social problem, and causes major economic losses. It is one of the most important information security issues. All ISPs strongly desire to reduce spam mail. In this section, we estimate the economic losses by spam mail.

First, we show that the essence of spam mail problem is in the mechanism that spammers (spam mail senders) can gain enough profits. Next, we estimate the economic losses caused by spam mail. We consider not only losses by labors but also the overinvestment in ICT assets. Therefore, the economic and social mechanism against spam mail needs to be designed.

6.1 Essence of spam Mail Problem

The essence of spam mail problem is based on the low cost, allowing a low response rate to lead to profits. According to Judge (2003), the cost of sending spam mail is $0.0005 per recipient, while the cost of sending direct postal mail is $1.21 per recipient. Direct mailers usually require a response rate of about 2%. On the other hand, spammers require even a response rate of about 0.001%[9].

Furthermore, tasks for sending spam mail are divided into the following three parts – collecting e-mail addresses, getting mail servers illegally, and sending spam mail. Each task is taken by professionals who gain enough profits. The mechanism to lead to profits is completed in sending spam mail.

6.2 Economic Losses by spam Mail

There are some reports that analyzed the economic losses caused by spam mail[10]. However, these reports estimate only the economic losses by labors. Actually, spam mail uses network resources, namely mail servers and computer networks, to send it. But, we don't know any reports that estimate overinvestment in information-communication infrastructures. We show the estimation of not only losses by labors but also overinvestment in ICT assets in U.S.A. and Japan.

First of all, we introduce the findings by Rockbridge Associates (2005). It is based on a random sample of U.S. adults and is administered by telephones. The sample size is 1000. U.S.

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[8] The definition of spam mail is "unsolicited commercial email sent indiscriminately and in great volume without receivers' consent" in this paper.

[9] A suspect man arrested for one click fraud in Osaka on June 6 2006 is saying "1000 people visited the site and 10-20 persons paid money as sending 1 million messages of spam mail."

[10] For example, see Nucleus Research (2004).

online adults receive 18.5 messages of spam mail a day on average. They spend 8.12 minutes on deleting spam mail a week on average. Consequently, the economic losses by labors amount to $21.6 billion per year in U.S.A.

Next, we calculate the economic losses by labors in Japan, following Rockbridge Associates (2005). Japanese online adults receive 4.86 messages of spam mail a day on average, according to the findings of the Ministry of Economy, Trade and Industry (METI) in Japan[11]. They spend 2.13 minutes on deleting spam mail a week on average, supposing that time to spend on deleting spam mail is the same as that in U.S.A. Therefore, the economic losses by labors amount to ¥181 billion per year in Japan.

Now, we consider the wasted network resources used to send spam mail. We should take account of computer networks and mail servers. First, we pick up computer networks. We find that the number of packets to deliver mail is less than 1% in total packets, according to Internet Scan Data Acquisition System (ISDAS) of Japan Computer Emergency Response Team Coordination Center (JPCERT CC)[12]. We neglect overinvestment in computer networks.

We consider the wasted mail servers used to send spam mail. The number of servers is 208 million in U.S.A. and 19.5 million in Japan respectively in January, 2005[13]. As we find the number of mail servers is 10% of the total number of servers according to our second questionnaire results[14], the number of mail servers is 20.8 million in U.S.A. and 1.95 million in Japan respectively. Investigation of Symantec says that 65% or more of e-mail is spam mail in July, 2004[15]. We assume that we could drop the performance of a mail server on a half, if spam mail did not exist. The average price of a mail server is about ¥360 thousand, according to the Statistical data of Japan Electronics and Information Technology Industries Association (JEITA) in 2004[16]. We presume that a server whose price is ¥240 thousand is sufficient to process it. Therefore, we estimate the overinvestment in ICT assets is¥250 million in U.S.A. and ¥23 million in Japan respectively.

We summarize the economic losses by spam mail in U.S.A. and Japan in Table 5. The overinvestment in ICT assets is more than the economic losses by labors in both U.S.A. and Japan. We have to study how to prevent not only receiving spam mail but also sending out it.

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11 http://www.iajapan.org/anti_spam/event/2005/conf0510/pdf/3-2.pdf (in Japanese)

12 http://www.jpcert.or.jp/isdas/ (in Japanese)

13 http://www.isc.org/index.pl?/ops/ds/reports/2005-01/dist-bynum.php

14 See Ebara, Nakaniwa, Takemura and Yokomi (2006) in detail.

15 http://www.symantec.com/region/jp/enterprise/articles/20040810.html (in Japanese)

16 http://it.jeita.or.jp/statistics/midws/h16/9-work.html (in Japanese)

Table 5. Economic Losses by spam Mail in U.S.A. and Japan

	U.S.A.	Japan
No. of spam Messages Received per Day	18.5	4.86
Economic Losses by Labors (billions)	$21.6	$1.7
Overinvestment in ICT Assets (billions)	$23.8	$2.2

$1 = ¥104.9 (Nov. 2004)

6.3 Implications

The countermeasures against spam mail are mainly based on filtering now. We can reduce the economic losses by labors but cannot reduce the overinvestment in ICT assets in the countermeasures based on filtering. Therefore, the economic and social mechanism like sender authentication (to verify the identity of the sender) needs to be suggested. For that purpose, major ISPs and the government must take the lead and discuss the unification of the authentication method. Furthermore, we have to reduce the profitability of sending spam mail. We have to manage computer security at all times and prevent hackers from taking possession of computers remotely. Therefore, the education of information security by the government is really important.

7 Conclusions

In this paper, we analyzed the management performance on ISPs quantitatively and qualitatively by questionnaires and interviews. We found the difference between nationwide and local providers by the statistical methods. On the one hand, the additional services like content services are important for nationwide providers. On the other hand, the community-friendly services are important for local providers. Furthermore, information security issues are very important for every provider. We suggested several policy implications on ISPs.

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