The pricing strategy of VoIP service providers

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Abstract

With the tremendous growth in smart phone market and the expanding coverage of communication and wireless networks, there is a new page opened in Voice over Internet Protocol (VoIP) telephony services. Internet Telephony Service Providers (ITSPs) take advantages of telecommunication (telecom) companies' effort to offer advance usage -- "VoIP-to-PSTN (Public Switched Telephone Network)" services. In this paper, we apply game theory analysis techniques to gain further insight on the subtle pricing strategy between ITSPs and telecoms, and find out on what kind of circumstances users will be willing to subscribe the VoIP-to-PSTN services.

Keywords: VoIP, PSTN, game theoretical analysis.

1. Introduction

VoIP telephony service is becoming the focus of the world attention, since it offer an extremely cheap telephony especially in long-distance call. Skype as a pioneer in VoIP services since 2003, has hold for millions of users all over the world till now. Yet the firm didn't start to profit until it launched "SkypeOut service" in 2004, which let users of Skype can call their friends who only subscribe to PSTN systems from their PC or VoIP phone device with a cheaper fee. It is because that ITSP can deliver customers' voice package through IP network to local PSTN system, thus the services can help saving more money while making long-distance calls. The profit gained from SkypeOut service forms a major part of the revenue of the whole company.

Recently, more and more ITSPs have sprung up, such as Fring, Nimbuzz and other ITSPs. With the pace of the previous, they offer free services that people can talk to friends who also subscribe for the same services without paying any extra money based on the calls. Then they start to charges for advanced "call-out" function. However, before any ITSP wants to offer the VoIP-to-PSTN service, it is necessary for him to sign a contract with telecoms to get a rational access fee. For these ITSPs, how much is the reasonable price they should charge based on the access fee and marketing strategy? That's a question waited to be answered.

Another aspect of VoIP services is that with the hope of making more profit for ITSPs, how to attract more users to subscribe to VoIP-to-PSTN service is the main issue. Like traditional telecommunication services, VoIP services particularly exhibits perhaps the highest degree of network externalities, which means users aren't willing to subscribe to a service knowing that no one else does. Thus the company may try to expanding their market segment in order to rise the degree of network externalities. Yet for users' point of view, quantity of users isn't the only thing matters. The quality of telephony and the ability that VoIP services can integrate with plenty original services, such as email, Short Message Service (SMS) and webpage browsing functions also effect the decisions of users. In this paper, we'll take all concepts above into consideration, and find out in what condition users will be willing to subscribe to VoIP service.

2. Related Topics and Lite rapture

In this section, the related issues of this

game theory analysis will be introduced and discussed. We introduce the game theory analysis techniques in section 2.1 while several research reports about VoIP services are covered in section 2.2

2.1 The Game Theory

Game theory is a mathematically theory dealing with the strategic situations that the individual's final outcome depends on others' choices [4]. It is original a branch of applied mathematics which is most notably in economics, and has been applied to variety of competition strategy, especially in information technology research field, such as peer production on Web 2.0 related services [3], knowledge sharing of software outsourcing [1] and E-commerce [2].

With game theoretical analysis, we can explore IT industry from an economic view. We can see what strategy will a company take under specific time and conditions. As in [5], the authors indicated the new IT architecture -- on-demand service will shift the fixed-cost into variable cost computing with game theoretical techniques. The author also pointed out that it's interesting to further study the fee and pricing structures in the market.

2.2 VoIP service provider

VoIP, also known as Internet telephony, is the technology that enables people to use the Internet, rather than the traditional PSTN, as the transmission medium for voice communications [7]. The crucial reason that ITSPs can help with monetary saving is that its P2P structures directly connect between talkers, not pass any central server to switch the packages. Thus it can save lots of fixed cost for facility purchase and maintenance than traditional telecoms.

Although there is a saying that VoIP service will take over traditional PSTN service and hence shake the position of telecoms [8], the new technologies still comes with some challenges, such as security and privacy issues like wiretapping [9] and the quality-of-services along with timing issue while voice package transmitting between VoIP network and PSTN system [6].

3. The Model

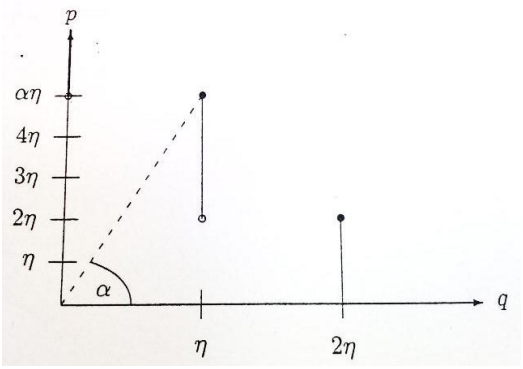
First we derive the demand function for internet telecommunication services. Since the demand of it seems to be similar with traditional telecommunication services or e-mail services which in particular exhibits perhaps the highest degree of network externalities. That is, users aren't willing to subscribe to an internet phone service knowing that nobody else does. Under the crucial property of externality, we construct a demand function taking into account that network externalities play a major role in consumers' demand for VoIP phone services.

3.1 Demand function

Consider there are two types of consumers who want to connect to a certain internet telecommunication services including η type H consumers placing high value on connecting the VoIP service and η type L consumers placing a lower value for this service. Let p present the connection fee to this service and q the actual number of users to this service. Then the utility function of each type is derived as follow:

$$U_H \stackrel{\text{def}}{=} \begin{cases} \alpha q - p & \text{connected} \\ 0 & \text{disconnected} \end{cases}$$
$$U_L \stackrel{\text{def}}{=} \begin{cases} q - p & \text{connected} \\ 0 & \text{disconnected} \end{cases} \quad (1)$$

where α measures the degree of the importance user cares about this service. According to Text book, we assume that α>4 which implies that type H consumers highly attach importance to this service. Then we construct the demand function for connecting to internet telecommunication services in the economy. The figure below shows the quantity demanded at each connection fee.



We found that type H consumer are willing to use the services as long as there are η consumers use this service, while type L consumers are willing to use given that all the 2ηconsumers use this service.

Therefore we can divide price range into 3 segments:

Low-price range ($0 \leqq p \leqq 2\eta$): The quantity demanded is 2η consumers due to the both nonnegative utility of two types of users.

Medium-price range ($2\eta < p < \alpha\eta$): Only the type H consumers will be involved in this range, whereas the type L consumers are better off not using the service.

High-price range ($p > \alpha\eta$): No one subscribes since both utilities of type H and L are negative.

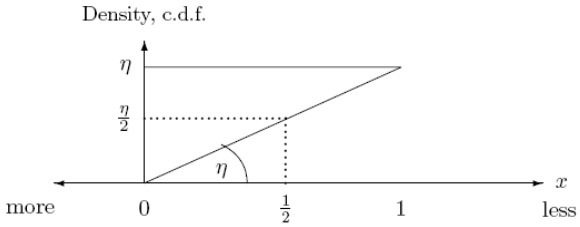
As we know that type H consumer will use the service as long as the connection fee drop in the range of p≤αq, the critical mass at a given connection fee p_0 is:

$$q^{cm}(p_0) = \frac{p_0}{\alpha} \quad (2)$$

Hence we can derive from the equation above that if the connection fee p = 0 then the critical mass $q^{cm} = 0$. On the contrary, if $p = \alpha\eta$, then $q^{cm} = \eta$(all type H consumers).

Finding the critical function can help the internet telephony company to understand how much advertising in needed to popularize new services — once q^{cm} consumers buy the service, more consumers will follow up even after advertising expenditure is reduced.

We've been focus our discussion on discrete distribution of customer type, now we consider a group of a η continuum of potential telephony customers uniformly indexed by x on the unit interval[0,1](with density η>0). We interpret customers indexed by a low x as those who have high willingness to pay (those who place a high valuation on their ability to communicate), and consumers indexed by a high x as those who have low willingness to play (less desire for subscribing to this service). Figure shown below provides a visual interpretation to the distribution of the potential customers.



We denote by q, $0 \leqq q \leqq 1$ the total number of consumers who actually subscribe to this service, and by p the connection fee(or the price) of subscribing to this service we define the utility of a consumer type x, $0 \leqq x \leqq 1$, as

$$U_x \stackrel{\text{def}}{\equiv} \begin{cases} (1-x)q^e - p & \text{if one subscribes} \\ 0 & \text{if one dose not subscribes} \end{cases} \quad (3)$$

Where q^e is consumers' expected number of customers subscribing to this telecommunication network. Thus, the utility of each customer exhibits network externalities since it increases with q^e which is the expected total number of customers.

We now derive the consumers' aggregate demand for VoIP services. We first look at a particular consumer denoted by $\hat{x}$ who is, at a given connection fee *p*, *indifferent* between subscribing and not subscribing to this service.

For a connection fee $p \leqq q^e$implies that this indifferent consumer is found from

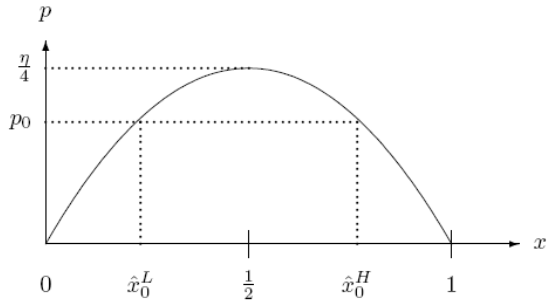
$$0 = (1-\hat{x})q^e - p, \quad or\ \hat{x} = \frac{q^e - p}{q^e} \quad (4)$$

Thus, all consumers indexed by $x > \hat{x}$ will not subscribe to this service, whereas all consumers indexed by $x \leq \hat{x}$ will subscribe. Hence, the actual number of

customers is $q = \eta\hat{x}$. Notice that $\hat{x}$ increases whenever q^e increases reflecting the fact that under network exteralities more peiple subscribe to a communication service with a higher expected number of customers. A natural question to ask is how the expected number of customers is determined. There are many things that may afect consumers' expectation of how many people will actually subscribe to this service, such as the advertising campaigns of the suppliers. However, in economics it is common to avoid speculations and to assume that consumers will attempt to obtain the correct information. We, therefore, make the following assumption.

Consumers have a perfect foresight. Formally, $q^e = q = \eta x$.

Substituting $q^e = \eta x$ *into Equation 4 yields the invers demand function for telephony services,* $p = (1-\hat{x})\mu\hat{x}$ *which can be depicted as the figure below.*



This figure also reveals the effect of a uniform increase in the population of all types of potential customers in this economy, as reflected by the increase in the density parameter η. A increment in η raises the peak of the curve, meaning that customers increase their willingness to pay. For example, if η doubles, customers are willing to pay double the connectoin fee, sincethey benefit from twice the network size (twice the number of people to make VoIP calls or to communicatie via add-ons through these apps.)

3.2 Profit of Monopoly internet telecommunication service provider

Since Skype is the first mover of internet telephony service provider on PC, when the smart phone era began, it goes without saying that Skype has leaded the whole market. Skype brings its Skype-out service into smart phone industry as a value-up function in its application, and so as to gain more profit from connection fee. At first it is the only one firm that cooperated with telecom to offer phone-out services, other VoIP service providers can only offer free connection between its users or provides phone-out service by integration with user's account of Skype. Thus we consider a single firm supplying internet connections on smart phone to the market, the demand function facing the monopoly is given by

$$q = \begin{cases} 2\eta & \text{if } 0 \le p \le 2\eta \\ \eta & \text{if } 2\eta < p \le \alpha\eta \\ 0 & \text{if } p > \alpha\eta \end{cases} \quad (5)$$

We assume that the firm needs to bear a connection-independent fixed cost φ, where$\varphi < min\{\eta(\alpha\eta - \mu),\ 2\eta(2\eta - \mu)\}$. In addition, the monopoly needs to pay μ units of money, where $\mu < \eta$. Thus we derive the profit of Skype as a monopolist as below:

$$\pi(p) = \begin{cases} 2\eta(p-\mu) - \varphi & \text{if } 0 \le p \le 2\eta \\ \eta(p-\mu) - \varphi & \text{if } 2\eta < p \le \alpha\eta \\ 0 & \text{if } p > \alpha\eta \end{cases} \quad (6)$$

A we assumed that $\alpha > 4$ which implies that$\eta(\alpha\eta - \mu) > 2\eta(2\eta - \mu)$, Skype's profit-maximizing price and profit level would be

$$p = \alpha\eta \quad \text{and} \quad \pi = \eta(\alpha\eta - \mu) - \varphi$$

which implies that all η type L consumers are not served.

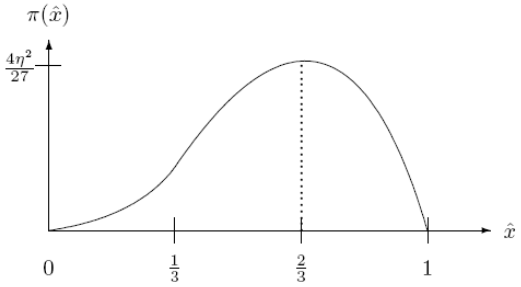
Again, we consider the condition of continuous distribution of customer type. We look back at the time that only skype is providing VoIP servicesand assume that Skype does not have fixed, connection and sunk costs and that the marginal cost of adding a customer is negligible. We now ask which connection fee maximizes the Skype's profit. To solve this problem, we formulate the monopoly's profit-maximization problem, which is to choose

$\hat{x}$ that solves

$$\max_{\hat{x}} \pi(\hat{x}) \overset{def}{=} p\eta\hat{x} = (1-\hat{x})(\eta\hat{x})^2 \quad (7)$$

This profit function is drqwn in the figure below. The first- and second-order conditions for *equation 4* are

$$0 = \frac{d\pi}{dx} = (2x-3x^2)\eta^2 \text{ and } \frac{d^2\pi}{dx^2} = (2-9x)\eta^2$$



Now, *Equation 5* and this figure completely describe how the profit level is affected by changing the number of customers. Clearly, the profit is zero when there are no customers ($\hat{x} = 0$). The profit is also zero when the entire population is connected to this service, since in order to have the entire population subscribing, the monopoly should reduce the connection fee to zero.

The first-order condition shows that $\hat{x} = 0$ and $\hat{x} = 2/3$ are local optimal points. In addition, the second-order condition shows that the second derivative is negative for $\hat{x} > 1/3$, implying that $\hat{x} = 2/3$ is a local maximum point. Since the first-order condition is positive for all $0 < \hat{x} < 2/3$, it must be that $\hat{x} = 2/3$ is a global maximum point. To find the connection fee charged by the monopoly and the profit level, substitute $\hat{x} = 2/3$ into (5.10) and into (5.12) to obtain

$$p = (1-\hat{x})\eta\hat{x} = \frac{2\eta}{9}, \text{ and } \pi = (1-\hat{x})(\eta\hat{x})^2 = \frac{4\eta^2}{27} \quad (8)$$

Hence, we can see the proposition:
A monopoly phone company maximizes its profit by setting its connection fee so that the number of customers exceeds half of the consumer population but is less than the entire population.

3.3 Entry of new firms

As we mentioned in the background of Skype, it cancel the complimentary service which allow other VoIP services to use Skype's Skype-out service. Hence, other firms bring out their own phone-out services one after another.

Since the internet telephony service providers need to bargain with telecoms to negotiate a reasonable price of their phone-out connection fee, we assume that telecoms will instruct the incumbent monopoly not to reduce its connection fees after entry of a competing provider is completed since they want more demand of connections from different companies so ad to balance the price.

Hence, consider a new internet telecommunication provider entering the industry after the ηtype H consumers have already purchased internet telephony services from the incumbent firm—Skype. Thus we construct the residual demand for the entrant as followed:

$$q^e = \begin{cases} \eta & \text{if } p \leq 2\eta \\ 0 & \text{if } p > 2\eta \end{cases}$$

Therefore, the entrant's profit-maximizing connection fee and profit level are:

$$p^e = 2\eta \text{ and } \pi^e = \eta(2\eta - \mu) - \varphi$$

Consider the utility function mentioned above, the main consumers who benefit most from entry in to internet telephony industry is type H consumers since the utility of them was $U_H = \alpha\eta - \alpha\eta = 0$ before and $U_H = \alpha 2\eta - \alpha\eta = \alpha\eta > 0$ after entry. Yet for type L consumers, the utility remain unchanged.

Conclusion

Since the prevalence of smart phone and wireless internet technology, the VoIP services on smart phone are getting more

and more popular. As a successful leader in the VoIP service on PC field, can Skype again conquer the VoIP market on Smart phone field? We imitate the book "The Economics of Network Industries" and derived some equation to see the Service Strategy of VoIP service provider on smart phone and found that it's quite similar with the strategy of telecommunication services providers. Due to the property of externality of telecommunication itself, rise in quantity of users will increase the utilities of users as such. It's very different with traditional products or services such as computers or mp3 players.

Next we found that there are different types of users in the market which have different degrees of preference to the same service. We assume the quantity of each type of consumers and derive profit-maximizing price and profit level of Skype. The outcome shows that Skype might chose to service only high level of consumers who highly value the VoIP services if the degree of the importance user cares about this service is high (from previous section, $\alpha>4$).

At first Skype is analogous to monopoly, yet since other VoIP service providers keep on showing up one after another, all of the internet telephony service providers need to rethink about their service strategy to contend with each other. According to our project, we know that the service strategy should base on what kind of customer the firm is going to serve and the consumer's preference of service. The game of firms like VoIP services providers is so complicated that our project cannot fully consider all the details, but it's still a good question worthy of contemplation.

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