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Analysis of Information Service Pricing Scheme Model Based on Customer Self-Selection

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Abstract
This study attempts to analyze pricing schemes with monitoring cost and marginal cost for perfect substitute and quasi-linear utility functions for achieving Internet service Provider (ISP) in gaining benefit. Two types of customers analyzed, namely customers who are heterogeneous (both high-end and low-end) as well as heterogeneous customers (high-demand and low-demand) based on Flat-fee, usage-based, and two-part tariff are the three types of pricing methods employed. The results show that usage-based pricing schemes gain maximum profit optimal for heterogeneous customers (high-end and low-end), while for heterogeneous customers (high-demand and low-demand) type of pricing scheme two-part tariff obtains maximum profit optimal. The results of this study are more directed to the lemma of the perfect substitute utility function which compares the lemma of heterogeneous customers. This model was solved using LINGO 13.0 software and ISP to get maximum profit.

Keywords
Utility Function, Perfect Substitute, Marginal Cost, Monitoring Cost, Pricing Schemes, Heterogeneous Customers

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1. INTRODUCTION

Internet is a tool for technology that can be used to reach the information needs of its customers. Internet service providers or ISPs try to share the best capacity to internet users and to achieve the highest revenue (Indrawati et al., 2015). Bundling is a strategy carried out by combining two or more specific products into a sales package (Gu et al., 2011; Kopczewski et al., 2018; Yassine et al., 2018; Ye et al., 2017).

The utility function Sitepu et al. (2016) is usually related to the satisfaction level that users receive compensation for the use of information services, especially those related to maximizing profits in achieving certain goals and namely as $A = i(m_1, m_2, \ldots, m_{\hat{n}})$ which means that $m_1, m_2, \ldots, m_{\hat{n}}$ contribute user utility (Kuo and Liao, 2007; Merayo et al., 2017) indicating goal-satisfaction. Further research on current internet pricing schemes has involved other utility functions that are often used such as the original Cobb-Douglas utility function (Puspita et al., 2020b; Sitepu et al., 2017b), quasi-linear, perfect substitute (Sitepu et al., 2017a), and bandwidth function (Guan et al., 2008; Indrawati et al., 2015; Zu-Xin et al., 2009; Moriya et al., 2005) utilized in three types of information service pricing systems, namely flat-fee, usage-based and two-part tariff (Gizelis and Vergados, 2010; Puspita et al., 2020a; Puspita et al., 2021) both analytically and as MINLP (Mixed Integer Nonlinear Programming) (Barrios and Cruz, 2017; Giraldo, 2017) with the help of LINGO (Cunningham and Schrage, 2004; Schrage, 2009) application software. The perfect substitute utility function was one important utility function to be selected to measure the satisfaction of the customers due to its linearity. The utility function is measurements of customer satisfaction indirectly (Hitt and Chen, 2005).

So far, past research focus on the pricing of information pricing schemes have been conducted (Indrawati et al., 2014; Sitepu et al., 2017b; Sitepu et al., 2017a; Wu and Banker, 2010) and also with the added parameters such as marginal dan monitoring costs. However, this research only focus on the pricing for information services without considering customer self-selection (Rabbani et al., 2017). Customer self-selection is based on packages or schemes (Varadarajan, 2020) to be offered to various customers (Rabbani et al., 2017). In this recent situation, customer self-selection through products or services offered is critical and needs to be developed, so it causes a gap that has to be explored more. The research needs to be critically explained in detail to show the relationship between the pricing scheme of information service and the ability of customers to select its service (Zhou et al., 2020).

Then, our contribution will be exploring new formulations through lemmas to show which pricing methods provide the most effective models that can be adopted by customers based on his/her preferences (Li et al., 2013). The customers can choose the schemes, due to its heterogeneity (Caiati et al., 2020; Kopczewski et al., 2018; Zhang et al., 2018).

2. METHOD

In this study, the customer self-model that the model was designed to have the eligibility of a customer to choose his/her preference pricing schemes fitted with his/her needs and budget, was compiled and validated using a local data server with a perfect substitute utility function, then the optimal results could be compared. The steps are listed as follows:

1. Modeling a pricing structure for the information services based on a quasi-linear utility function with flat-fee, usage-based, and two-part tariff pricing types for heterogeneous customer problems.
   a) For service pricing schemes on flat-fee,
   b) For service pricing schemes on usage-based,
   c) For service pricing schemes on two-part tariff
2. Applying the scheme for optimal pricing based on data on the local server in the form of traffic data. Processing this data from a local server in the form of traffic data on the LPSE application, concerning with tool equipment available for the institution.
3. Validating a quasi-linear utility function for diverse customer types based on three types of pricing schemes: flat-fee, usage-based, and two-part tariff, with the addition of marginal expenses and monitoring costs.
4. Comparing the pricing scheme models obtained from the analysis in Step 3 to obtain the optimal pricing scheme for each type of customer, namely high-end and low-end and high-demand and low-demand heterogeneous customers.
5. Make conclusions and get the best information service pricing solutions.

3. RESULTS AND DISCUSSION

3.1 Perfect Substitute Utility Functions for High-end and Low-end Customers

In this instance, the perfect substitute utility function with the form $A(m, n) = xm + yn$. Suppose there are high-end customers ($j = 1$) and low-end customers ($j = 2$) where

$$\alpha_1 + \alpha_2 = 1$$

Customer Problem Optimization:

$$\underset{M,N,O}{\text{Max}}\ Op = xM + yN - R_m M - R_n N - RO - (M+N)k \quad (1)$$

with constraints:

$$M \le \bar{M}O \quad (2)$$

$$N \le \bar{N}O \quad (3)$$

$$xM + yN - R_m M - R_n N - RO - (M+N)k \le 0 \quad (4)$$

$$O = 0 \text{ or } 1 \quad (5)$$

Where R_m is ISP' fixed price in peak hour, R_n is ISP' fixed price in off peak hour, O is the customer decision to join the schemes or not, k is marginal and monitoring cost, M is the largest amount of data consumed during peak hours, measured in kilobytes and N is the maximum level of usage in kilobytes during off-peak hours.

Service Provider Problem Optimization:

$$\underset{R,R_M,R_N}{\text{Max}}\ \sum_j (R_m M^* + R_n N^* + RO^*) \quad (6)$$

where $(M^*, N^*, O^*) = \text{argmax}\, xM + yN - R_m M - R_n N - RO - (M+N)k$ subject to Equation (2)-(5).

where R is customer fees for joining the service.

The Objective Function (6) is used to maximize user overload according to the price set by the service provider. This model does not consider the initial cost for customers to join. But through This model can consider the long-term relationship between providers services and customers but does not charge for the short term or a certain period of time. O=0 or 1 is determined by the costumer, where if the customer chooses not to join the program then will be 0 so that $M \le \bar{M}O$ and $M \le \bar{M}O$ will be worth 0. Meanwhile, if the customer chooses to join the program, then O will be worth. The value of M and N can not exceed the limit of $\bar{M}$ and $\bar{N}$. For usage-based and two-part tariff pricing schemes:

Customer Problem Optimization:

$$\underset{M,N,O}{\text{Max}}\ Op = xM + yN - R_m M - R_n N - RO - (k+l)M - (k+l)N \quad (7)$$

Subject to Equation (2)-(3), and (5), also

$$xM + yN - R_m M - R_n N - RO - (k+l)M - (k+l)N \ge 0 \quad (8)$$

Service Provider Problem Optimization:

$$\underset{R,R_M,R_N}{\text{Max}}\ \sum_j (R_m M^* + R_n N^* + RO^*) \quad (9)$$

where $(M^*, N^*, O^*) = \text{argmax}\, xM + yN - R_m M - R_n N - RO - (k+l)M - (k+l)N$ subject to Equation (2), (3), (5), and (8).

Case 1: Flat-fee pricing scheme for heterogeneous customers (high-end and low-end) based on a perfect substitute utility function with marginal costs and monitoring costs

$$\begin{aligned}\text{Max}_R\, \alpha_1(RO_1^*) + \alpha_2(RO_2^*) &= \alpha_1(x_2\bar{M} + y_2\bar{N} - (M+N)k) + \alpha_2 (x_2\bar{M} + y_2\bar{N} - (M+N)k) \\ &= (\alpha_1 + \alpha_2)(x_2\bar{M} + y_2\bar{N} - (M+N)k)\end{aligned}$$

The maximum benefits for the service provider will be $(\alpha_1 + \alpha_2)(x_2\bar{M} + y_2\bar{N} - (M+N)k)$; where m is the number of high-end customers and n is the number of low-end customers. This analysis is summed up in Lemma 1.

Lemma 1: If the ISP uses a flat-fee pricing scheme, the price charged to customers will be $x_2\bar{M} + y_2\bar{N} - (M+N)k$ and the maximum profit earned is $(\alpha_1 + \alpha_2)(x_2\bar{M} + y_2\bar{N} - (M+N)k)$.

Case 2: A usage-based pricing is method based on a perfect substitute utility function for heterogeneous users (high-end and low-end) with marginal costs and monitoring costs. If the ISP chooses to use a usage-based pricing scheme, then it is set to $R_m > 0, R_n > 0$, and $R = 0$, so that the optimization of customer problems becomes:

$$\underset{M_j, N_j, O_j}{\text{Max}} \quad Op = x_jM_j + y_jN_j - R_mM_j - R_nN_j - R(0) - (k+l)M_j - (k+l)N_j$$

$$\underset{M_j, N_j, O_j}{\text{Max}} \quad Op = x_jM_j + y_jN_j - R_mM_j - R_nN_j - (k+l)M_j - (k+l)N_j$$

Optimization of high-end heterogeneous customer problems: To maximize Equation (6), a differentiation is made to the low-end heterogeneous customer optimization problem as follows. To maximize the Equation, a differentiation is made to M_1 and N_1; under the conditions of $\frac{\partial O_p}{\partial M_1} = 0$ and $\frac{\partial O_p}{\partial N_1} = 0$

$$\leftrightarrow \frac{\partial(x_1M_1 + y_1N_1 - R_mM_1 - R_nN_1 - (k+l)M_1 - (k+l)N_1)}{\partial M_1} = 0$$

$$\leftrightarrow x_1(k+l) = R_m$$

and

$$\leftrightarrow \frac{\partial(x_1M_1 + y_1N_1 - R_mM_1 - R_nN_1 - (k+l)M_1 - (k+l)N_1)}{\partial N_1} = 0$$

$$\leftrightarrow y_1(k+l) = R_m$$

Service Provider Problem Optimization becomes:

$$\begin{aligned}
&\underset{R, R_m, R_n}{\text{Max}} \quad \alpha_1(R_MM_1^* + R_NN_1^*) + \alpha_2(R_MM_2^* + R_NN_2^*)\\
&= \underset{R_m, R_n}{\text{Max}} \quad \alpha_1((x_1 - (k+l))M_1^* + (y_1 - (k+l))N_1^*)\\
&\quad + \alpha_2((x_2 - (k+l))M_2^* + (y_2 - (k+l))N_2^*)\\
&= \underset{R_m, R_n}{\text{Max}} \quad \alpha_1(x_1M_1^* + y_1N_1^* - (k+l)M_1^* - (k+l)N_1^*)\\
&\quad + \alpha_1(x_2M_2^* + y_2N_2^* - (k+l)M_2^* - (k+l)N_2^*)
\end{aligned}$$

In order to maximize the optimization equation for the producer problem, the ISP must minimize the value of R_m and R_n. Since M_1, M_2, N_1, and N_2 are constrained, M_1^*, M_2^*, N_1^*, and N_2^* cannot exceed $\bar{M}$ and $\bar{N}$.To find the maximum cost, analysis during peak hours has been done. This analysis is applied to problems during peak and off-peak hours. Specifically, R_m and R_n will be $R_m = x_2 - (k+l)$ and $R_n = y_2 - (k+l)$ with the maximum profit obtained is: $(\alpha_1 + \alpha_2)(x_2\bar{M} + y_2\bar{N} - (k+l)\bar{M} - (k+l)\bar{N})$. Based on this case, the following Lemma 2 is obtained.

Lemma 2: If ISP utilizes the usage-based pricing scheme, the optimal prices will be $R_m = x_2 - (k+l)$ and $R_n = y_2 - (k+l)$ with the maximum profit gained is $(\alpha_1 + \alpha_2)(x_2\bar{M} + y_2\bar{N} - (k+l)\bar{M} - (k+l)\bar{N})$.

Case 3: Two-part tariff pricing scheme for heterogeneous customers (high-end and low-end) based on a perfect substitute utility function with marginal costs and monitoring costs.

If ISP chooses to select a two-part tariff scheme then it will be set $R_m > 0, R_n > 0$, and $R > 0$. Then, R_M will be obtained that ranges between $x_1 - (k+l)$ and $x_2 - (k+l)$ or $x_2 - (k+l) \leq R_m \leq x_1 - (k+l)$ and so does R_n. The best price for R_m should be between x_1 and x_2. When the prices are within this interval then the high-end customer demands will be fixed at $\bar{M}$ and low-end customer demands will be proportional to a price decrease. Meaning, R_m and R_n will be $R_m = x_2 - (k+l)$, $R_n = y_2 - (k+l)$, and $R = 0$. Assume that $x_1 < \frac{\alpha_1+\alpha_2}{\alpha_1}x_2$ and $y_1 < \frac{\alpha_1+\alpha_2}{\alpha_1}y_2$. Then, the ISP problem will be:

$$\begin{aligned}
\underset{P_x, P_y}{\text{Max}} \quad &\alpha_1(R_MM_1^* + R_NN_1^* + RO_1^*) + \alpha_2(R_MM_2^* + R_NN_2^* + RO_2^*)\\
&\alpha_1((x_2 - (k+l))M_1^* + (y_2 - (k+l))N^* + 0)\\
&+\alpha_2((x_2 - (k+l))M_2^* + (y_2 - (k+l))N^* + 0)\\
&\alpha_1(x_2M^* - (k+l)M^* + y_2N^* - (k+l)N^*)\\
&+\alpha_2(x_2M^* - (k+l)M^* + y_2N^* - (k+l)N^*)\\
&= (\alpha 1 + \alpha_2)(x_2M^* + y_2N^* - (k+l)M^* - (k+l)N^*)
\end{aligned}$$

The maximum profit will be

$$(\alpha_1 + \alpha_2)(x_2\bar{M} + y_2\bar{N} - (k+l)\bar{M} - (k+l)\bar{N})$$

Then, this analysis is to be summarized in Lemma 3.

Lemma 3: If ISP uses a two-part tariff scheme, the optimal price will be $R_m = x_2 - (k+l)$, $P_n = y_2 - (k+l)$, and R=0 with the maximum profit of $(\alpha_1 + \alpha_2)(x_2\bar{M} + y_2\bar{N} - (k+l)\bar{M} - (k+l)\bar{N})$.

3.2 Perfect Substitute Utility function for High-demand and Low-demand Heterogeneous Customers

With a maximum degree of usage, it is assumed that there are two sorts of customers: high-demand customers (type 1) and low-demand customers (type 2) $\bar{M}_1$, and $\bar{N}_1$ for (type 1) and $\bar{M}_2$ and $\bar{N}_2$ for (type 2) where $\bar{M}_1 > \bar{M}_2$ and $\bar{N}_1 > \bar{N}_2$. Suppose there are m high-demand customers and n low-demand customers with $x_1 = x_2 = x$ and $y_1 = y_2 = y$. Then, determination of the maximum profit on each pricing scheme used by the ISP.

Case 4: Flat-fee pricing scheme for heterogeneous customers (high-demand and low-demand) based on a perfect substitute utility function with marginal costs and monitoring costs.

If using a flat-fee pricing scheme, it is determined that $R_m = 0, R_n = 0$, and $R > 0$. This means that if customers choose to join the given program, then the maximum level of satisfaction is obtained by choosing the level of consumption with the maximum level of satisfaction obtained will be $M_1 = \bar{M}_1$, $N_1 = \bar{N}_1$, or $M_2 = \bar{M}_2$, $N_2 = \bar{N}_2 x\bar{M}_1 + y\bar{N}_1 - (\bar{M}_1 + \bar{N}_1)k$ or $x\bar{M}_2 + y\bar{N}_2 - (\bar{M}_2 + \bar{N}_2)k$. So, ISP cannot charge more than $x\bar{M}_1 + y\bar{N}_1 - (\bar{M}_1 + \bar{M}_1)k$ to every high-demand customer and every low-demand customer $a\bar{M}_2 + b\bar{N}_2 - (\bar{M}_2 + \bar{N}_2)k$. By using a flat-fee pricing scheme, ISPs cannot distinguish pricing between high-demand customers and low-demand customers, so ISPs must choose to charge a fee of $x\bar{M}_1 + y\bar{N}_1 - (\bar{M}_1 + \bar{N}_1)k$ and only high-demand customers can use the service or charge a fee of $x\bar{M}_2 + y\bar{N}_2 - (\bar{M}_2 + \bar{N}_2)k$ where high-demand customers and low-demand customers can join the given program. If it is assumed that $\alpha_1[x\bar{M}_1 + y\bar{N}_1 - (\bar{M}_1 + \bar{N}_1)k] < (\alpha_1 + \alpha_2)[x\bar{M}_2 + y\bar{N}_2 - (\bar{M}_2 + \bar{N}_2)k]$, then the best price that can be charged by the ISP is $x\bar{M}_2 + y\bar{N}_2 - (x\bar{M}_2 + y\bar{N}_2)k$ for high-demand customers and low-demand customers. So, the maximum profit that the ISP obtained is:

$$(\alpha_1 + \alpha_2)(x\bar{M}_2 + y\bar{N}_2 - (\bar{M}_2 + \bar{N}_2)k)$$

Based on the analysis, the following Lemma 4 is obtained.

Lemma 4: If the ISP uses a flat-fee pricing scheme, the fee paid becomes $P = x\bar{M}_2 + y\bar{N}_2 - (\bar{M}_2 + b\bar{N}_2)k$ and the maximum profit obtained is:

$$(\alpha_1 + \alpha_2[x\bar{M}_2 + y\bar{N}_2 - (\bar{M}_2 + \bar{N}_2)k]$$

Case 5: Based on a perfect substitute utility function, a usage-based pricing method for heterogeneous customers (high-demand and low-demand) is proposed with marginal costs and monitoring costs. If the ISP chooses to use a usage-based pricing scheme, then it is determined that $R_m > 0$, $R_n > 0$, and $R = 0$. For optimization of the high-demand/low-demand customer problem results in:

$$\underset{M,N,O}{\text{Max}}\ Op = xM_j + yN_j - R_mM_j - R_nN_j - (k+l)M_j - (k+l)N_j$$

Optimization of high-demand heterogeneous customer problems:
To optimize Equation (7), differentiate toward M_1 and N_1; with conditions as following.
$\frac{\partial O_p}{\partial M_1} = 0$ and $\frac{\partial O_p}{\partial N_1} = 0$

$$\leftrightarrow \frac{\partial(xM_1 + yN_1 - R_mM_1 - R_nN_1 - (k+l)M_1 - (k+l)N_1)}{\partial M_1} = 0$$

$$\leftrightarrow x(k+l) = R_m$$

and

$$\leftrightarrow \frac{\partial(xM_1 + yN_1 - R_mM_1 - R_nN_1 - (k+l)M_1 - (k+l)N_1)}{\partial N_1} = 0$$

$$\leftrightarrow y(k+l) = R_n$$

Low-demand heterogeneous customer problem optimization:

In order to optimize Equation (7), a differentiation is made to M_2 and N_2; with conditions
$\frac{\partial O_p}{\partial M_2} = 0$ and $\frac{\partial O_p}{\partial N_2} = 0$

$$\leftrightarrow \frac{\partial(xM_2 + yN_2 - R_mM_2 - R_nN_2 - (k+l)M_2 - (k+2)N_2)}{\partial M_2} = 0$$

$$\leftrightarrow x(k+l) = R_m$$

and

$$\leftrightarrow \frac{\partial(xM_2 + yN_2 - R_mM_2 - R_nN_2 - (k+l)M_2 - (k+2)N_2)}{\partial N_2} = 0$$

$$\leftrightarrow y(k+l) = R_n$$

Then, the Service provider problem can be derived as follows:

$$\underset{P,P_x,P_y}{\text{Max}}\ \alpha_1(R_mM_1^* + R_nN_1^*) + \alpha_2(R_mM_2^* + R_nN_2^*)$$
$$= \alpha_1(xM_1^* + yN_1^* - (k+l)M_1^* - (k+l)N_1^*) + \alpha_2(xM_2^* + yN_2^* - (k+l)M_2^* - (k+l)N_2^*)$$

If M_1, M_2, M_1, and M_2 are limited, then M_1^*, M_2^*, N_1^*, and N_2^* will be $\bar{M}_1, \bar{M}_2, \bar{N}_1$, and $\bar{N}_2$. Then, R_m, and R_y will be $R_m = x - (k+l)$, and $R_n = y - (k+l)$ with the maximum profit of $\alpha_1(x\bar{M}_1 + y\bar{N}_1 - (k+l)\bar{M}_1 - (k+l)\bar{N}_1) + \alpha_2(x\bar{M}_2 + y\bar{M}_2 - (k+l)\bar{M}_2 - (k+l)\bar{N}_2)$.
This analysis is concluded in the following lemma.

Lemma 5: If the ISP uses a usage-based pricing scheme, the optimal price is $R_m = x - (k+l)$, and $R_n = b - (k+l)$ with the maximum profit obtained is:

$$\alpha_1(x\bar{M}_1 + y\bar{N}_1 - (k+l)\bar{M}_1 - (k+l)\bar{N}_1) + \alpha_2(x\bar{M}_2 + y\bar{N}_2 - (k+l)\bar{M}_2 - (k+l)\bar{N}_2)$$

Case 6: Two-part tariff pricing scheme for heterogeneous customers (high-demand and low-demand) based on a perfect substitute utility function with marginal costs and monitoring costs. If the ISP chooses to use a two-part tariff pricing scheme, it will be determined that $R_m > 0$, $R_n > 0$, and $R > 0$. For the optimization process on the optimization of the problem of high-demand customers and low-demand customers, then

$$x\bar{M}_j + y\bar{N}_j - R_m\bar{M}_j - R_n\bar{N}_j - R(1) - (k+l)\bar{M}_j - (k+l)\bar{N}_j \geq 0$$
$$\leftrightarrow x\bar{M}_j + y\bar{N}_j - (x-(k+l))\bar{M}_j - (y-(k+l))\bar{N}_j - R - (k+l)\bar{M}_j - (k+l)\bar{N}_j \geq 0$$
$$\leftrightarrow x\bar{N}_j + y\bar{N}_j - x\bar{M}_j + (k+l)\bar{M}_j - y\bar{N}_j + (k+l)\bar{N}_j - R - (k+l)\bar{M}_j - (k+l)\bar{N}_j \geq 0$$
$$\leftrightarrow -R \geq 0$$
$$\leftrightarrow R \leq 0$$

Because P cannot be negative or $R < 0$, then $R = 0$.

Table 1. Recapitulation of Pricing Schemes for Different Customer Types

Customer Type	Pricing Scheme	Profit
Heterogeneous: High-end & Low-end	Flat fee	$(\alpha_1+\alpha_2)(x_2\bar{M}+y_2\bar{N}-(\bar{M}+\bar{N})k$
	Usage-based Two-part tariff	$(\alpha_1+\alpha_2)(x_2\bar{M}+y_2\bar{N}-(k+l)\bar{M}-(k+l)\bar{N})$
Heterogeneous: High-demand & Low-demand	Flat fee	$(\alpha_1+\alpha_2)(x\bar{M}_2+y\bar{N}_2-(\bar{M}_2+\bar{N}_2)k$
	Usage-Based Two-part tariff	$\alpha_1(x\bar{M}_1+y\bar{N}_1-(k+l)\bar{M}_1-(k+l)\bar{N}_1)+$ $\alpha_2(x\bar{M}_2+y\bar{N}_2-(k+l)\bar{M}_2-(k+l)\bar{N}_2)$

Therefore, the Service Provider problem will be

$$\begin{aligned}\underset{R,R_m,R_n}{\text{Max}}\ & \alpha_1(R_mM_1^*+R_nM_1^*+R)+\alpha_2(R_mM_2^*+R_nN_2^*+R)\\ =\underset{R,R_m,R_n}{\text{Max}}\ & \alpha_1((x-(k+l))M_1^*+(y-(k+l))N_1^*+R)\\ & +\alpha_2((x-(k+l))M_2^*+(y-(k+l))N_2^*+R)\\ =\underset{R,R_m,R_n}{\text{Max}}\ & \alpha_1(xM_1^*+yN_1^*-(k+l)M_1^*-(k+l)N_1^*)\\ & +\alpha_2(xM_2^*+yN_2^*-(k+l)M_2^*-(k+l)N_2^*)\end{aligned}$$

If M_1, M_2, N_1 and N_2 are constrained, then M_1^*, M_2^*, N_1^* and N_2^* will be $\bar{M}_1, \bar{M}_2, \bar{N}_1$ and $\bar{N}_2$. In other words, $R_m = x-(k+l)$, $R_n = y-(k+l)$, and $R = 0$ with the maximum profit obtained is:

$$\alpha_1(xM_1^*+yN_1^*-(k+l)M_1^*-(k+l)N_1^*)+\alpha_2(xM_2^*+yN_2^*-(k+l)M_2^*-(k+l)N_2^*)$$

So, the following lemma is summarized.

Lemma 6 : If the ISP uses a two-part tariff pricing scheme, the optimal price is $R_m = x-(k+l)$, $R_n = y-(k+l)$, and $R = 0$ with the maximum profit obtained is:

$$\alpha_1(xM_1^*+yN_1^*-(k+l)M_1^*-(k+l)N_1^*)+\alpha_2(xM_2^*+yN_2^*-(k+l)M_2^*-(k+l)N_2^*)$$

Table 1 displays the maximum profit gained for each scheme. By setting the parameter values assigned for each parameter as stated in Table 2, the values for each profit can be determined. The value of $\bar{M}$ and $\bar{N}$ is collected from the average demand of bandwidth consumption of LPSE traffic data from a local server in one of the institutions in Palembang for one month at the beginning of March 2021. The data is not used to build the model, but the data is for the validation model only. The data value is used to show or to validate the value obtained from the formulation for each lemma. Table 2 depicts the values.
Where $\bar{M}_1 = \bar{M}$ is the largest amount of data consumed during peak hours, measured in kilobytes.
$\bar{M}_2$ without obtaining data is the maximum consumption rate during peak hours $\bar{X}_1$, so $\bar{M}_1>\bar{M}_2$.

Table 2. The Values of $\bar{M}$ and $\bar{N}$ from LPSE Traffic Data

Notation	Ipse
$\bar{M}_1$ or $\bar{M}$ (kilobyte)	0.00185874
$\bar{M}_2$ (kilobyte)	0.061958
$\bar{N}_1$ or $\bar{N}$(kilobyte)	0.00181696
$\bar{N}_2$ (kilobyte)	0.060565

$\bar{N}_1$ or $\bar{N}$ is the maximum level of usage in kilobytes during off-peak hours.
$\bar{N}_2$ is the greatest rate of consumption during off-peak hours, excluding data retrieval $\bar{Y}_1$, so $\bar{N}_1>\bar{N}_2$.

Based on Table 3, the maximum profit obtained is in the flat-fee pricing scheme, which is equal to $(\alpha_1+\alpha_2)(0.00185874\, x_2 + (0.00181696)y_2 - 0.0036757k)$ for High-end and Low-end Heterogeneous customers. Meanwhile, for high-demand and low-demand heterogeneous customers, the maximum profit is by utilizing usage-based and two-part tariff schemes, that are

$$\begin{aligned}&\alpha_1(0.061958x+0.060565y-0.128525k(k+l))\\ &+\alpha_2(0.061958x+0.060565y-0.128525k(k+l))\end{aligned}$$

4. CONCLUSIONS

This paper focuses on how to design a model based on customer self-selection on deciding which pricing scheme suit for heterogeneous customers. The data of the local server of LPSE is used to show the validation of the model that can be solved. Based on the results of the analysis and discussion, it can be concluded as follows. The best pricing scheme for heterogeneous customers (high-end and low-end) is found using a flat fee pricing scheme, while pricing strategies for heterogeneous customer (high-demand and low-demand) is obtained using a pricing scheme based on the perfect substitute utility function. the most optimal was usage-based with the customers can be satisfied by selecting the schemes on his/her preferences. For further research, the concept of bundling strategy is likely to be considered in the schemes due to its advantages more customers to choose the service.

Table 3. Recapitulation of Pricing Schemes for Different Customer Types

Customer Type	Pricing Scheme	Profit
Heterogeneous: High-end & Low-end	Flat fee	$(\alpha_1+\alpha_2)(0.00185874x_2 + (0.00181696)y_2 - 0.0036757k)$
	Usage-based Two-part tariff	$(\alpha_1+\alpha_2)(0.00185874x_2 + (0.00181696)y_2 - 0.0036757(k+l))$
Heterogeneous: High-demand & Low-demand	Flat fee	$(\alpha_1+\alpha_2)(0.061958x + 0.060565y - 0.128525k)$
	Usage-Based Two-part tariff	$\alpha_1(0.061958x + 0.060565y - 0.128525k(k+l))+$ $\alpha_2(0.061958x + 0.060565y - 0.128525k(k+l))$

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