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Model and Optimal Solution of Multi Link Pricing Scheme in Multiservice Network

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ABSTRACT

Background: In this paper, we will design new internet pricing scheme in multiservice network based on Puspita *et al*. (2013c). The new scheme is established by setting the base price, premium quality and quality of service (QoS). Objective: The scheme was made to help internet service providers (ISPs) to maximize revenue and provide better service quality for users. The objective function is formed by setting the base price and premium quality as a variable or constant. The model will be used in the form of nonlinear equations and solved by LINGO 11.0 get better optimal solution by setting the base price and premium quality as variables or constants. **Results:** The optimal solution for each case is the total maximum profit that service provider set up. If the service provider intends to increase the profit, the service provider will apply the case by varying the base price and the quality premium and setting up the QoS level for each service is treated as the same quality. **Conclusion:** There is a relationship between many links, QoS levels, the amount of capacity being used and the capacity provided by the service provider. In this scheme, the service provider is able to achieve its goal of maximizing profits and maintaining the best service to users. In the improved model, we obtain a new parameter, additional variables and additional constraints in accordance with any modifications.

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INTRODUCTION

Multiservice networks are used to serve a variety of services and applications with different characteristics in time, connection support and the quality of service (Sain & Herpers, 2003). Given models can basically meet the demands and objectives of the ISP. Suppose that the i level of service consumption, ISPs can maximize i consumer surplus at some certain level of consumption, where k indicates the multi-link.

According to Byun and Chatterjee (2004) the pricing model for Internet services based on different levels of quality by focusing on pricing schemes on the basis of usage because that scheme reflects the level of congestion in depth.

Research on improved models on the internet pricing schemes under single link multiservice networks (Irmeilyana *et al*. (2013); Irmeilyana *et al*. (2014a)) are based on models that have been modified by Puspita *et al*. (2014; 2012a, 2012c) and a network of multi-class QoS (Irmeilyana *et al*. (2014a); Irmeilyana *et al*. (2014b); Irmeilyana *et al*. (2014b)) are based on models that have been modified by Puspita *et al*. (2011; 2011b; 2012b, 2013a; 2013c; 2013d). We will define the basic price, premium quality and QoS level to generate the maximum profit for ISPs that is better than previous model. The model used is based on the basic price (α) as constants and quality premium (β) and β variables. The results obtained are applied to the three (3) services for multi-service networks and two (2) user (user services) with 2 (two) classes at a network of multi-class QoS. In fact, the ISP should provide a much improved quality of service and a lot of class to the many users of the network.

In the study proposed by Puspita *et al*. (2012a) an optimization model to obtain the maximum revenue by using an improved model based on the results of Byun and Chatterjee (2004) and Sain and Herpers (2003) in multiservice network is conducted. Optimal results can be solved by using LINGO 11.0 to obtain the better maximum revenue. The advantage of this study is to enable internet service providers (ISPs) to manage the base price and quality premium.

So, the contribution is created by improving the mathematical formulation of (Byun & Chatterjee, 2004; Puspita *et al*., 2012a; Puspita, Seman, Taib, & Shafii, 2013b; Yang, 2004) into new formulation by taking into

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consideration the utility function, base price as fixed price or variable, quality premium as fixed prices and variable, index performance condition, capacity in more than one link in each class or in each service and also bandwidth required. The problem of internet charging scheme is considered as Mixed Integer Nonlinear Programming (MINLP) to obtain optimal solution. In this part, the comparison of two models is conducted in which whether decision variable is to be fixed of user admission to the class or not.

Our contribution will be a new modified on solving internet charging scheme of multi link multi service networks Again, we formulate the problem as MINLP that can be solved by nonlinear programming method to obtain exact solution.

RESEARCH METHOD

In this paper, to complete the pricing schemes in order to obtain maximum results we use LINGO 11.0 program. First we define variables and parameters that are needed in order to obtain the maximum benefit for the Internet service provider to produce the solution which allows to interpret and explain the pricing scheme, network and QoS class capacity.

IMPROVED MODELS

The initial models obtained from Puspita *et al*. (2013c) Model ini diperoleh dari (Puspita *et al*., 2013b) with a base price and premium quality as well as using the index of service quality as variable. After we modify the model, we can use it as a new model. We vary the possibilities of the index quality, quality premium and base price, respectively as follows.

$I_i = I_{i-1}$ or $I_i > I_{i-1}$ or $I_i < I_{i-1}$. (1)
$\beta_i = \beta_{i-1}$ or $\beta_i > \beta_{i-1}$ or $\beta_i < \beta_{i-1}$. (2)
$\alpha_i = \alpha_{i-1}$ or $\alpha_i > \alpha_{i-1}$ or $\alpha_i < \alpha_{i-1}$. (3)

RESULT AND DISCUSSION

Based on the value of the parameters and variables that have been defined by Puspita *et al*. (2013c) for the case when the base price and premium quality services as variable to obtain maximum results. We will modify the models to yield better solutions repaired models with multiple parameters and variables are like the index of service quality, the price of basic services, and premium quality for each service like those conditions (1)-(3) explained.

Here, ISP operates the services with a total capacity of 33620 kbps in link 1 and 4357 kbps in link 2. Then, we solve the MINLP model. We determine two main classifications by setting up α and β as variables and α as variable and β is fixed. Table 1 explains the solutions when we set up $\alpha_i = \alpha_{i-1}$ dan $\beta_i = \beta_{i-1}$ but different requirements for I_i and I_{i-1}. The most optimal solution is when setting up $\alpha_i = \alpha_{i-1}$, $\beta_i = \beta_{i-1}$ and $I_i = I_{i-1}$ which is 1564.5 unit price. Total capacity used is 35715 kbps or 94.04% from capacity available. The most capacity used is in service 3 of 37977 kbps. For $I_i > I_{i-1}$, there is no optimal solution.

Table 1. Solutions when $\alpha_i = \alpha_{i-1}$ dan $\beta_i = \beta_{i-1}$

Requirement	$I_i = I_{i-1}$			$I_i > I_{i-1}$		
Service	i=1	i=2	i=3	i=1	i=2	i=3
Base Price	1	1	1	1	1	1
Quality Premium	0.5	0.5	0.5	0.5	0.5	0.5
Shared Capacity	0.3	0.3	0.3	0.3	0.3	0.3
QoS level	0.1	0.1	0.1	0.01	0.03	0.05
Number of User	10	10	10	10	10	10
Capacity Used (link 1)	33492	60	68	33492	60	68
Capacity Used (link 2)	2223	82	2052	2223	82	2052
Total Capacity	37977			37977		
Profit per service (link 1)	31.5	472.5	157.5	30.15	456.75	153.75
Profit per service (link 2)	63	588	252	60.3	568.4	246
Total Profit	1564.5			1515.35		

Other case when setting up the case for $\alpha_i = \alpha_{i-1}$ dan $\beta_i > \beta_{i-1}$ is presented in Table 2. For $I_i = I_{i-1}$ we obtain the highest optimal solution of 1597,1. The capacity used is 35715 kbps or 94,04% of total service provided. The

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most used capacity is in service 3 of 37977 kbps. In case when $\alpha_i = \alpha_{i\text{-}1}$ dan $\beta_i > \beta_{i\text{-}1}$ for $I_i < I_{i\text{-}1}$ we do not obtain optimal solution. Table 3 below, describes the solution when we set up $\beta_i < \beta_{i\text{-}1}$. For three cases, we got the same profit of 1522.28.

Table 2. Solutions when $\alpha_i = \alpha_{i\text{-}1}$ dan $\beta_i > \beta_{i\text{-}1}$

Requirement	$I_i = I_{i\text{-}1}$			$I_i > I_{i\text{-}1}$		
Service	i=1	i=2	i=3	i=1	i=2	i=3
Base Price	1	1	1	1	1	1
Quality Premium	0.6	0.7	0.8	0.6	0.7	0,8
Shared Capacity	0.3	0.3	0.3	0.3	0.3	0,3
QoS level	0.1	0.1	0.1	0.01	0.03	0.05
Number of User	10	10	10	10	10	10
Capacity Used (link 1)	33492	60	68	33492	60	68
Capacity Used (link 2)	2223	82	2052	2223	82	2052
Total Capacity	37977			37977		
Profit per service (link 1)	31.8	481.5	162	30.18	459.45	156
Profit per service (link 1)	63.6	599.2	259.2	60.36	571.76	249.6
Total Profit	1597.1			1527.35		

Table 3. Solutions when $\alpha_i = \alpha_{i\text{-}1}$ and $\beta_i < \beta_{i\text{-}1}$

Requirement	$I_i > I_{i\text{-}1}$		
Service	i=1	i=2	i=3
Base Price	1	1	1
Quality Premium	0.5	0.6	0.7
Shared Capacity	0.3	0.3	0.3
QoS level	0.01	0.03	0.05
Number of User	10	10	10
Capacity Used (link 1)	33492	60	68
Capacity Used (link 2)	2223	82	2052
Total Capacity	37977		
Profit per service (link 1)	30.15	458.1	155.25
Profit per service (link 2)	60.30	570.08	248.4
Total Profit	1522.28		

Table 4. Solutions when $\alpha_i > \alpha_{i\text{-}1}$ and $\beta_i = \beta_{i\text{-}1}$

Requirement	$I_i = I_{i\text{-}1}$			$I_i > I_{i\text{-}1}$			$I_i < I_{i\text{-}1}$		
Service	i=1	i=2	i=3	i=1	i=2	i=3	i=1	i=2	i=3
Base Price	0.5	0.6	0.7	0.5	0.6	0.7	0.5	0.6	0.7
Quality Premium	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Shared Capacity	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
QoS level	1	1	1	0.6	0.8	1	1	0.8	0.6
Number of User	10	10	10	10	10	10	10	10	10
Capacity Used (link 1)	33492	60	68	33492	60	68	33492	60	68
Capacity Used (link 2)	2223	82	2052	2223	82	2052	2223	82	2052
Total Capacity	37977			37977			37977		
Profit per service (link 1)	30	495	180	20.4	450	180	30	450	150
Profit per service (link 2)	60	616	288	40.8	560	288	60	560	240
Total Profit	1669			1539,2			1490		

Table 4 presents the case when $\alpha_i > \alpha_{i\text{-}1}$ and $\beta_i = \beta_{i\text{-}1}$. When we set up $I_i = I_{i\text{-}1}$ we obtain the highest maximum profit of 1669 unit price with total capacity used of 35715 or 94,04% of total capacity available. Again, with service 3 serves more service to consumers.

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Table 5. Solutions when $\alpha_i > \alpha_{i\text{-}1}$ and $\beta_i > \beta_{i\text{-}1}$

Requirement	$I_i = I_{i-1}$			$I_i > I_{i-1}$			$I_i < I_{i-1}$		
Service	*i*=1	*i*=2	*i*=3	*i*=1	*i*=2	*i*=3	*i*=1	*i*=2	*i*=3
Base Price	0.5	0.6	0.7	0.5	0.6	0.7	0.5	0.6	0.7
Quality Premium	0.6	0.7	0.8	0.6	0.7	0.8	0.6	0.7	0.8
Shared Capacity	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
QoS level	1	1	1	0.6	0.8	1	1	0.8	0.6
Number of User	10	10	10	10	10	10	10	10	10
Capacity Used link 1)	33492	60	68	33492	60	68	33492	60	68
Capacity used (link 2)	2223	82	2052	2223	82	2052	2223	82	2052
Total Capacity	37977			37977			37977		
Profit per service (link 1)	33	585	225	25.8	522	225	33	522	177
Profit per service (link 2)	66	728	360	51.6	649.6	360	66	649.6	283.2
Total Profit	1997			1834			1730.8		

When we set up $\alpha_i > \alpha_{i\text{-}1}$ and $\beta_i > \beta_{i\text{-}1}$ for $I_i = I_{i\text{-}1}$, as shown in Table 5, we obtain the highest optimal solution of 1997 unit price with capacity of 37977 kbps or 88,19%. The most used service is service 3 with capacity of 33492 kbps. Next, in Table 6, the maximum profit is obtained when we set up $\alpha_i > \alpha_{i\text{-}1}$ and $\beta_i < \beta_{i\text{-}1}$ for $I_i = I_i$-1 with the profit of 1490 unit price or 88,19% of total capacity available.

Table 6. Solutions when $\alpha_i > \alpha_{i\text{-}1}$ and $\beta_i < \beta_{i\text{-}1}$

Requirement	$I_i = I_{i-1}$			$I_i > I_{i-1}$			$I_i < I_{i-1}$		
Service	*i*=1	*i*=2	*i*=3	*i*=1	*i*=2	*i*=3	*i*=1	*i*=2	*i*=3
Base Price	0.2	0.6	0.7	0.5	0.6	0.7	0.2	0.5	0.7
Quality Premium	0.8	0.4	0.3	0.8	0.5	0.3	0.7	0.5	0.3
Shared Capacity	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
QoS level	1	1	1	0,6	0.8	1	0.9	0,7	0.6
Number of User	10	10	10	10	10	10	10	10	10
Capacity Used (link 1)	33492	60	68	33492	60	68	33492	60	68
Capacity Used (link 2)	2223	82	2052	2223	82	2052	2223	82	2052
Total Capacity	37977			37977			37977		
Profit per service (link 1)	30	450	150	29.4	450	150	24.9	382.5	132
Profit per service (link 2)	60	560	240	58.8	560	240	49.8	476	211.2
Total Profit	1490			1488.2			1286.4		

Table 7. Solutions when $\alpha_i < \alpha_{i\text{-}1}$ and $\beta_i = \beta_{i\text{-}1}$

Requirement	$I_i > I_{i-1}$		
Service	i=1	i=2	i=3
Base Price	0.65	0.575	0.5
Quality Premium	0.5	0.5	0.5
Shared Capacity	0.3	0,3	0.3
QoS level	0.5	0.75	1
Number of User	10	10	10
Capacity Used (link 1)	33492	60	68
Capacity Used (link 2)	2223	82	2052
Total Capacity	37977		
Profit per service (link 1)	27	427.5	150
Profit per service (link 2)	54	532	240
Total Profit	1430.5		

In Table 7, the optimal solution of 1430,5 unit price is obtained when setting up $\alpha_i < \alpha_{i\text{-}1}$ and $\beta_i = \beta_{i\text{-}1}$ for $I_i > I_{i\text{-}1}$ with capacity total of 37977 kbps or 88,19 % of capacity available. In service 3 the capacity used is the highest value of 33492 kbps. For other conditions, when I_i=$I_{i\text{-}1}$ and $I_i < I_{i\text{-}1}$ the optimal solutions cannot be achieved. For the case when $\alpha_i < \alpha_{i\text{-}1}$ and $\beta_i > \beta_{i\text{-}1}$ the solution is presented in Table 8. The highest optimal solution value is 1937 unit price with total capacity used is 37977 kbps. The service most used is service 3 with capacity of 33492 kbps.

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Table 8. Solutions when $\alpha_i < \alpha_{i-1}$ and $\beta_i > \beta_{i-1}$

Requirement	$I_i = I_{i-1}$			$I_i > I_{i-1}$		
Service	i=1	i=2	i=3	i=1	i=2	i=3
Base Price	0.7	0.6	0.5	0.7	0.6	0.5
Quality Premium	0.6	0.7	0.8	0.6	0.7	0.8
Shared Capacity	0.3	0.3	0.3	0.3	0.3	0.3
QoS level	1	1	1	0.6	0.8	1
Number of User	10	10	10	10	10	10
Capacity Used (link 1)	33492	60	68	33492	60	68
Capacity Used (link 2)	2223	82	2052	2223	82	2052
Total Capacity	37977			37977		
Profit per service (link 1)	39	585	195	31.8	522	195
Profit per service (link 2)	78	728	312	63.6	649.6	312
Total Profit	1937			1774		

Table 9. Solutions when $\alpha_i = \alpha_{i-1}$ and β fixed

Requirement	$I_i = I_{i-1}$			$I_i > I_{i-1}$		
Service	i=1	i=2	i=3	i=1	i=2	i=3
Base Price	0.5	0.5	0.5	0.5	0.5	0.5
Shared Capacity	0.3	0.3	0.3	0.3	0.3	0.3
QoS level	1	1	1	0,6	0,8	1
Number of User	10	10	10	10	10	10
Capacity Used (lin 1)	33492	60	68	33492	60	68
Capacity used (link 2)	2223	82	2052	2223	82	2052
Total Capacity	37977			37977		
Profit per service (link 1)	30	450	150	24	405	150
Profit per service (link 2)	60	560	240	48	504	240
Total Profit	1490			1371		

In Table 9, when $\alpha_i = \alpha_{i-1}$ and β fixed we obtain the highest maximum profit of 1490 unit price with total capacity used is 37977 or 88,19 % of total capacity available when we set up $I_i = I_{i-1}$. Again, the most service used is service 3 with capacity of 34992 kbps. For the case $I_i < I_{i-1}$ we do not obtain optimal solution.

Table 10. Solutions when $\alpha_i > \alpha_{i-1}$ and β fixed

Requirement	$I_i = I_{i-1}$			$I_i > I_{i-1}$			$I_i < I_{i-1}$		
Service	i=1	i=2	i=3	i=1	i=2	i=3	i=1	i=2	i=3
Base Price	0.5	0.6	0.7	0.5	0.6	0.7	0.4	0.6	0.7
Shared Capacity	0.5	0.4	0	0.3	0.3	0.3	0.3	0.3	0.3
QoS level	1	1	1	0.6	0.8	1	0.9	0.7	0.6
Number of User	10	10	10	10	10	10	10	10	10
Capacity Used (link 1)	33492	60	68	33492	60	68	33492	60	68
Capacity Used (link 2)	2223	82	2052	2223	82	2052	2223	82	2052
Total Capacity	37977			37977			37977		
Profit per service (link 1)	30	495	180	24	450	112.5	25.5	427.5	150
Profit per service (link 2)	60	616	288	48	560	180	51	532	240
Total Profit	1669			1374.5			1425		

The highest profit of 1669 unit price is achieved when we set up $\alpha_i > \alpha_{i-1}$ and β fixed for $I_i = I_{i-1}$ with capacity of 37977 kbps or 88,19% of total capacity available. The most service used is service 3 with 33492 kbps capacity used.

Tabel 11. Solutions when $\alpha_i < \alpha_{i\text{-}1}$ and β fixed

Requirement	$I_i > I_{i\text{-}1}$		
Service	i=1	i=2	i=3
Base Price	0.7	0.6	0.5
Shared Capacity	0.2	0.4	0.4
QoS level	0.6	0.8	1
Number of User	10	10	10
Capacity Used (link 1)	33492	60	68
Capacity Used (link 2)	2223	82	2052
Total Capacity	37977		
Profit per service (link 1)	30	450	150
Profit per service (link 2)	60	560	240
Total Profit	1490		

Table 11 shows the optimal solution of 1490 unit price is achieved when we set up $\alpha_i < \alpha_{i\text{-}1}$ and β fixed for $I_i > I_{i\text{-}1}$ with capacity used is 37977 kbps or 88,19% of total capacity used.

The most service used is service 3 with capacity used of 33492 kbps For case when $I_i = I_{i\text{-}1}$ or $I_i < I_{i\text{-}1}$ we do not obtain optimal solutions.

From above results, the optimal solution for each case is the total maximum profit that service provider set up. If the service provider intends to increase the profit, the service provider will apply the case by varying the base price and the quality premium and setting up the QoS level for each service is treated as the same quality.

If we compare with the previous results, we obtain better results in terms of number of users apply the services. In our results, each service can pursue the users to utilize the services since there is no 0 users apply the service compared to previous results. The base price, in our results could be varied with the additional constraints to meet the requirement for each case. In our results the share of network capacity, the capacity used is fully utilized by the users. There is 0 capacity in each service. It enables the service providers to calculate the profit. There is no zero profit in each service.

CONCLUSION

Improving the model by modifying many links, the quality index, the price of premium quality basic and applied can be considered by the service providers to achieve maximum benefit. The results showed that there is a relationship between many links, QoS levels, the amount of capacity being used and the capacity provided by the service provider. In this scheme, the service provider is able to achieve its goal of maximizing profits and maintaining the best service to users.

In the improved model, we obtain a new parameter, additional variables and additional constraints in accordance with any modifications. In further experiments, the larger size of the services offered are considered to be closer to the real situation in the network.

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