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Model and Optimal Solution of Single Link Pricing Scheme Multiservice Network

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Abstract

This paper discussed the new improved and modified internet pricing scheme in multiservice networks [1]. This new improved scheme is created to set up the base price, quality premium and Quality of service (QoS). This scheme has the purposes to help Internet Service Provider (ISP) in maximizing the revenue and contribute better quality of service to the users. The objective function will be formed to set up the base price and quality premium as a variable or a constant. The models used are in nonlinear forms and solved by using LINGO 11.0 to get the optimal solution. The results show that for each cases of improved scheme, ISP gets better optimal solutions by varying or fixing the base price and quality premium.

Keywords*: internet pricing, quality of service, internet service provider, base price, quality premium*

1. Introduction

Internet has an important role in development of global economy. Internet Service Provider provides best service to fulfill user needs [1]. ISP competes in increasing their service quality and maximizes the revenue with that quality. The way to provide maximum revenue is by providing Quality of Service (QoS) [2-4] for users. By giving the different level of services, ISP is able to improve the new resources for itself and the company using this new framework can improve new digital product [5] .

Pricing scheme problem actually is not a new case for ISP. ISP has to find a new way to echieve their goals. Determining the product or service price is a critical task that should be fulfilled by an organization. With the right price, the company can gain the consumers, maintain and obtain the profit [5]. ISP deals with the preference of users to use flat fee pricing scheme due to its simplicity and profitability. The customers are able to access all internet connection with only pay monthly subscription fee. However, this scheme is not profitable to ISP. ISP should be able to come up with the new pricing scheme that is profitable for them.

The pricing scheme in multiservice network by considering the prices, capacity allocation and QoS in maximizing ISP profit is investigated in [1, 6, 7]. This basic optimization model is proposed to determine the optimal solution of capacity allocation, QoS level for each class and maximum user for each service.

ISP offers some chosen service qualities that are suitable for users' need and budget. The customers will get the best by paying the highest price or otherwise. [8-18] have investigated the improved internet pricing scheme in multi QoS networks. ISP gets some choices to adapt the new improved model according to ISPs' goals.

The contribution of this paper basically to give improvement of the improved pricing scheme proposed previously by [1, 6, 7] by considering cases to vary the quality index, base price and quality premium. Based on that improved model, the ISP can determine which schemes offer best pricing strategy that can be adopted.

2. Research Method

In this paper, we will solve the optimization problem by using LINGO 11.0. We are given the parameters and asked to find the variable solutions in maximizing ISP profit. After modeling the formulation, we solve the model by using the tool to get the optimal solution. The solutions are enabling us to interpret and explain the trends in pricing scheme, network, capacity and QoS level.

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3. Improved Models

The models is adopted in [1] with the additional constraints for base price, quality premium and the QoS levels as follows. If we require to vary the QoS level differently or each service, then the three possibilities are

$$I_i = I_{i-1} \text{ or } I_i > I_{i-1} \text{ or } I_i < I_{i-1}. \quad (1)$$

If it is required to also vary the quality premium to enable the service providers to promote certain services then

$$\beta_i = \beta_{i-1} \text{ or } \beta_i > \beta_{i-1} \text{ or } \beta_i < \beta_{i-1}. \quad (2)$$

If the requirements are to vary the base price in order to enable the service providers to have market competitions then

$$\alpha_i = \alpha_{i-1} \text{ or } \alpha_i > \alpha_{i-1} \text{ or } \alpha_i < \alpha_{i-1}. \quad (3)$$

4. Results and Analysis

In solving the problem of pricing scheme model, we adopt the same models, parameters and variables stated in [1] for the case when we set up base price as variable but we have different ways in maximizing the revenue. We will improve the models by modifying some parameters and variables such as index quality, base price and quality premium for each service. We have to consider every case for determining the parameter and variables.

So a network provider operates a multi service network with a total capacity of 102400 kbps. We use LINGO 11.0 to solve the optimization model. This problem is called mixed integer nonlinear programming (MINLP) since there exists at least one nonlinear equation.

We determine two main classifications by setting up α and β as variables dan α as variable and β is parameter. 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 when setting up $\alpha_i = \alpha_{i-1}$, $\beta_i = \beta_{i-1}$ and $I_i = I_{i-1}$ is 504 unit price. Total capacity used is 8550 kbps or 8.35% from capacity available. The most capacity used is in service 3 of 7500 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	0.5	0.5	0.5	0.5	0.5	0.5
Quality Premium	0.3	0.3	0.3	0.3	0.3	0.3
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	600	450	7500	360	360	7500
Total Capacity		8550			8220	
Profit per service	24	360	120	20.4	333	120
Total Profit		504			473.4	

Table 2. 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	0.5	0.5	0.5	0.5	0.5	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	600	450	7500	360	360	7.500
Total Capacity		8550			8220	
Profit per service	33	540	195	25,8	477	195
Total Profit		768			697.8	

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 768. The capacity used is 8550 kbps or 8.35% of total service provided. The most used capacity is in service 3 of 7500 kbps. In case when $\alpha_i = \alpha_{i-1}$ dan $\beta_i > \beta_{i-1}$ untuk $I_i < I_{i-1}$ we do not obtain optimal solution.

In Table 3, the case when we set up $\alpha_i = \alpha_{i-1}$ dan $\beta_i < \beta_{i-1}$ is presented. The optimal solution is obtained when the case is for $I_i > I_{i-1}$ of 504 unit price. The capacity used for this case is 8115 or 7.92% of total capacity available. We do not obtain optimal solution for $I_i=I_{i-1}$ and $I_i<I_{i-1}$.

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

Requirement		$I_i > I_{i-1}$	
Service	i=1	i=2	i=3
Base Price	0.5	0.5	0.5
Quality Premium	0.6	0.4	0.3
Shared Capacity	0.3	0.3	0.3
QoS level	0.5	0.7	1
Number of User	10	10	10
Capacity Used	300	315	7500
Total Capacity		8115	
Profit per service	24	360	120
Total Profit		504	

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

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	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	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	1	0.8	0.6
Number of User	10	10	10	10	10	10	10	10	10
Capacity Used	600	450	7500	360	360	7500	600	360	4500
Total Capacity		8550				8220			5460
Profit per service	24	405	150	20.4	378	150	24	378	132
Total Profit		579				548.4			534

Table 4 presents the case when $\alpha_i > \alpha_{i-1}$ and $\beta_i = \beta_{i-1}$. When we set up $I_i = I_{i-1}$ we obtain the highest maximum profit of 579 unit price with total capacity used of 8550 or 8.35% of total capacity available. Again, with service 3 serves more service to consumers.

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

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	600	450	7500	360	360	7500	600	360	4500
Total Capacity		8550			8220			5460	
Profit per service	33	585	225	25.8	522	225	33	522	177
Total Profit		843				772.8			732

When we set up $\alpha_i > \alpha_{i-1}$ and $\beta_i > \beta_{i-1}$ for $I_i = I_{i-1}$, as shown in Table 5, we obtain the highest optimal solution of 843 unit price with capacity of 8550 kbps or 8.35%. The most used service is service 3 with capacity of 7500 kbps. Next, in Table 6, the maximum profit is obtained when we set up $\alpha_i > \alpha_{i-1}$ and $\beta_i < \beta_{i-1}$ for $I_i = I_i$.1 with the profit of 630 unit price or 8.35% of total capacity available.

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

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	600	450	7500	360	360	4500	540	315	4500
Total Capacity		8550			5220			5355	
Profit per service	30	450	150	29.4	450	150	21.9	382.5	150
Total Profit		630				629.4			554.4

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

Requirement		$I_i > I_{i-1}$	
Service	i=1	i=2	i=3
Base Price	0.65	0.575	0.5
Quality Premium	0.3	0,3	0.3
Shared Capacity	0.3	0,3	0.3
QoS level	0.5	0.75	1
Number of User	10	10	10
Capacity Used	300	337.5	7500
Total Capacity		8137.5	
Profit per service	24	360	120
Total Profit		504	

In Table 7, the optimal solution of 504 unit price is obtained when setting up $\alpha_i < \alpha_{i-1}$ and $\beta_i = \beta_{i-1}$ for $I_i > I_{i-1}$ with capacity total of 8137.5 kbps or 7.94% of capacity available. In service 3 the capacity used is the highest value of 7500 kbps. For other conditions, when I_i=I_{i-1} and $I_i < I_{i-1}$ the optimal solutions cannot be achieved.

For the case when $\alpha_i < \alpha_{i-1}$ and $\beta_i > \beta_{i-1}$ the solution is presented in Table 8. The highest optimal solution value is 819 unit price with total capacity used is 8550 kbps. The service most used is service 3 with capacity of 7500 kbps.

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	600	450	7500	360	360	7500
Total Capacity		8550			8220	
Profit per service	39	585	195	31.8	522	195
Total Profit		819			748.8	

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	600	450	7500	360	360	7500
Total Capacity		8550			8220	
Profit per service	21	315	105	18,6	297	105
Total Profit		441			420.6	

In Table 9, when $\alpha_i = \alpha_{i\text{-}1}$ and β fixed we obtain the highest maximum profit of 441 unit price with total capacity used is 8550 or 8.35% of total capacity available when we set up $I_i = I_{i\text{-}1}$. Again, the most service used is service 3 with capacity of 7500 kbps. For the case $I_i < I_{i\text{-}1}$ we do not obtain optimal solution.

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

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	0.4	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	600	450	7500	360	360	7500	540	315	4500
Total Capacity		8550		8220				5355	
Profit per service	21	360	135	18.6	342	135	17.4	333	123
Total Profit		516			495.6			473.4	

The highest profit of 516 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 of 8550 kbps or 8.35% of total capacity available. The most service used is service 3 with 7500 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	360	360	7500
Total Capacity	8220		
Profit per service	24.6	342	105
Total Profit	471.6		

Table 11 shows the optimal solution of 471.6 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 8220 kbps or 8.02% of total capacity used. The most service used is service 3 with capacity used of 7500 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 proposed on [1] 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.

5. Conclusion

The improving models by modifying the index quality, base price and quality premium can be considered to be applied by service providers in achieving the maximum profit. The results show that there exist the connections among QoS level, the number of capacity used and capacity provided by service provider. In these schemes, service provider is able to achieve its goal to maximize the profit and to maintain the best service to the users.

In these improved models, we gain the new parameters, additional variables and additional constraints according to each modification. In further research, the larger size of services offered is considered to approach the real situations in the networks.

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