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THE COMPARISON OF INTERNET PRICING SCHEME IN MULTI LINK BOTTLENECK MULTI SERVICE NETWORK

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ABSTRACT. In this research we set up pricing scheme of multilink internet bottleneck for multi-service network by giving the modified models and the solution. This model is based on the local server data in Palembang. Internet Service Provider (ISP) requires the appropriate pricing schemes in order to maximize revenue and provide quality services that can satisfy the Internet users. The model established by setting the base price (α) as constants and the premium quality of service (β) as variables and constants. Then the model will be solved using Program LINGO 13.0 to obtain the optimal solution. From the results obtained shows the optimal solution that ISP can use the models to generate maximum revenue and gives options according to the user needs in accordance with the goal of ISP. The optimal solution results compared to previous work show that the larger dimension of the problem, the goals can also change according to the needs. From LINGO 13.0, the solution for four services and 3 links offered were maximized when we set up the base price (α) as constants and the premium quality of service (β) as constants for Ii = Ii-1. So ISP can use the modification scheme to achieve its goals. The realistic case to be solved by LINGO 13.0 is limited to have only four services and three links.

Keywords: pricing scheme, multilink internet bottleneck, maximum revenue

INTRODUCTION

Along the progress of time, human in the modern era is not separated from the internet. Almost all society use the internet to support life. The increasing numbers of Internet users, the demands on quality are also getting bigger. The work discussed by He et al. (2012) explained that internet pricing can be classified according to cost analysis or as the economic models (Lee et al. 2013; Pal and Hui, 2013). The categories are flat pricing (Fruchter & P.Sigué, 2013), where ISPs charge the users with equal price and access. Other category is based on usage pricing, where the charges are based on the usage (S.-y. Wu & Banker, 2010) with the discussion of the fixed and the usage based pricing were discussed in Sen (2013) In addition, some research also focused on pricing in multiple QoS class networks in single link (Puspita et al., 2013b) or multiple links (Puspita et al., 2013a).

This is a big task for ISP to provide better and different Quality of Service (QoS), ISPs are required to provide a mechanism for proper planning of internet pricing where ISP as service providers and user as internet users (Malinowski et al. 2010; Marzolla and Mirandola, 2010;

Wu et al. 2010) . Internet pricing schemes that are often used are the internet flat rate, usage-based and two-part tariff (Wu et al., 2010; Wu and Banker2002).

Pricing schemes based on QoS levels in different allocations that control congestion and load balance is also critical (Gu et al. 2011) or the ability of user sensitivity in network through user's utility forms of form probability of packet loss, average packet delay, probability of packet tail, delay of maximum packet and also throughput (Gottinger, 2011). Other form of pricing scheme is based on the strategy as function of time (Safari et al. 2014). The optimal pricing strategy can also be considered to be dynamic pricing scheme in Castillo et al. (2013) and solution done numerically as partial differential equations.

Previous research about internet pricing single link multi service and multi-link and multi-service has been carried out by Seman et al. (2012), Puspita et al. (2015) , Puspita et al. (2012) which uses an improved model based on the results of Byun and Chatterjee (2004) and Sain and Herpers (2003) In this paper, we intend to extend the models into larger number of services required up to LINGO 13.0 (2008) solver' ability to solve the model. The generalized models are useful to get more information on how the LINGO 13.0 super edition software application solves the model. So our contribution here is to generalize the more realistic case of internet pricing scheme problem to maximize the provider profit based on multilink multiservice networks. The previous work done is only able to show that the models can be adopted to more realistic case of internet pricing.

RESEARCH METHOD

By forming a model based on parameters and variables that are used to settle the case we can create the mathematical programming problem. Then the model is solved using LINGO 13.0 to produce an optimal solution. The optimal solution is expected to assist ISP in obtaining the revenue with known quality of service. The models are considered as mixed integer nonlinear programming.

RESULTS AND DISCUSSIONS

We set up two cases, parameters and variables definitions as Puspita et al. (2015) explained. After several trials to generate models according to number of services and number of link, we finally come up with the limitation of number of parameter and variables of LINGO solvers to be only 4 services and 3 links offered.

Model Formulations

Case 1 (α and β constant)

The model equations are used for case 1 using the objective function and constraints of the equations (Puspita et al. 2015) with input parameter values of constraints with a large number of service (*s*) by 4 with *i* = 1 , 2 , 3 , 4.Based on the objective function as following.

$Max\ R = \sum_{k=1}^{3}\sum_{i=1}^{4}(\alpha + \beta . I_i) . p_{ik} . x_{ik}$ $=0.3x_{11}+1.5I_1x_{11}+4.5x_{21}+22.5I_2x_{21}+1.5x_{31}+0.75I_3x_{31}+1.1x_{41}+5.5I_4x_{41}+0.6x_{12}+3I_1x_{12}+2.1x_{22}+10.5I_2x_{22}+2.4x_{32}+12I_3x_{32}+1.8x_{42}+9I_4x_{42}+0.9x_{13}+4.5I_1x_{13}+3x_{23}+15I_2x_{23}+2.6x_{33}+13I_3x_{33}+1.2x_{41}+6I_4x_{41}$

Subject to :

$$5\,I_1x_{11} \le 838\,a_{11} \quad (1)$$
$$17\,I_2x_{21} \le 838\,a_{21} \quad (2)$$

$$815\ I_3 x_{31} \leq 838\ a_{31} \quad (3)$$
$$1 I_4 x_{41} \leq 838\ a_{41} \quad (4)$$
$$7\ I_1 x_{12} \leq 13244\ a_{12} \quad (5)$$
$$75\ I_2 x_{22} \leq 13244\ a_{22} \quad (6)$$
$$13244\ I_3 x_{32} \leq 13244\ a_{32} \quad (7)$$
$$1 I_4 x_{42} \leq 13244\ a_{42} \quad (8)$$
$$5\ I_1 x_{13} \leq 7922\ a_{13} \quad (9)$$
$$56\ I_2 x_{23} \leq 7922\ a_{23} \quad (10)$$
$$7861\ I_3 x_{33} \leq 7922\ a_{33} \quad (11)$$
$$1 I_4 x_{43} \leq 7922\ a_{43} \quad (12)$$
$$5\ I_1 x_{11} + 17\ I_2 x_{21} + 815\ I_3 x_{31} + 1 I_4 x_{41} \leq 838 \quad (13)$$
$$7\ I_1 x_{12} + 75\ I_2 x_{22} + 13.244\ I_3 x_{32} + 1 I_4 x_{42} \leq 13326 \quad (14)$$
$$5\ I_1 x_{13} + 56\ I_2 x_{23} + 7.861\ I_3 x_{33} + 1 I_4 x_{43} \leq 7922 \quad (15)$$
$$a_{11} + a_{21} + a_{31} + a_{41} = 1 \quad (16)$$
$$a_{12} + a_{22} + a_{32} + a_{42} = 1 \quad (17)$$
$$a_{13} + a_{23} + a_{33} + a_{43} = 1 \quad (18)$$
$$0 \leq a_{ij} \leq 1 \quad (19)$$
$$0{,}01 \leq I_{1,2,3,4} \leq 1 \quad (20)$$
$$0 \leq x_{ij} \leq 10 \quad (21)$$
$$\{x_{11}, x_{21}, x_{31}, x_{41}, x_{12}, x_{22}, x_{32}, x_{42}, x_{13}, x_{23}, x_{33}, x_{43}\} \subseteq Z^+ \quad (22)$$

By modifying the index quality of service *i* (I_i), the added constraints are as follows.

$$I_i = I_{i-1} \quad (23)$$
$$I_i > I_{i-1} \quad (24)$$
$$I_i < I_{i-1} \quad (25)$$

Case 2 (α constant and β variable)

Based on the objective function as follows.

$Max\ R = \sum_{k=1}^{3}\sum_{i=1}^{4}(\alpha + \beta_i . I_i). p_{ik}. x_{ik}$ =(0.1+ β_1 . I_1) $3x_{11}$ + (0.1+ β_2 . I_2) $45x_{21}$ +(0.1+ β_3 . I_3) $15x_{31}$ +(0.1+ β_4 . I_4)$11x_{41}$+(0.1+β_1)$6x_{12}$+(0.1+$\beta_2 . I_2$)$21x_{22}$+(0.1+$\beta_3 . I_3$)$24x_{32}$+(0.1+$\beta_4 . I_4$)$18x_{42}$+ (0.1 + β_1)$9x_{13}$+(0.1+$\beta_2 . I_2$)$30x_{23}$+(0.1+$\beta_3 . I_3$)$26x_{33}$+(0.1+$\beta_4 . I_4$)$12x_{43}$

Subject to Eq. (1) to Eq. (25), and added constraints:

$$\beta_2 I_2 \geq \beta_1 I_1 \quad (26)$$
$$\beta_3 I_3 \geq \beta_2 I_2 \quad (27)$$
$$\beta_4 I_3 \geq \beta_3 I_3 \quad (28)$$
$$0{,}01 \leq \beta_{1,2,3,4} \leq 0{,}5 \quad (29)$$
$$\beta_i = \beta_{i-1} \quad (30)$$
$$\beta_i > \beta_{i-1} \quad (31)$$
$$\beta_i < \beta_{i-1} \quad (32)$$

Model Solution in Multi Service Network using LINGO Program

Case 1 : α and β constant

Table 1 and 2 Display the results and the recapitulation with other cases.

Table 1. Optimal Solution of Case 1.

i	$I_i=I_{i-1}$		$I_i<I_{i-1}$	
	Total Capacity	Profit	Total Capacity	Profit
1	170	918	170	918
2	1480	4896	1480	4896
3	219200	3315	203856	3087.5
4	30	2091	27.9	1947.5
∑	220880	11220	205533.9	10849

Table 2. Recapitulation of Capacity dan Total Profit of Case 1.

Case	$I_i = I_{i-1}$	$I_i< I_{i-1}$
Total Capacity Used	220880	205533.9
Percentage of Total Capacity Used	100%	93.05%
Total Profit	11220	10849

Case 2 : α constant and dan β Variable

In Table 3 and 4, ISP get maximum profit if ISP set up $\beta_i = \beta_{i-1}$and $I_i>I_{i-1}$.

Table 3. Optimal Solution of Case 2.

i	$I_i=I_{i-1}$		$I_i<I_{i-1}$	
	Total Capacity	Profit	Total Capacity	Profit
1	170	918	159.8	187.2
2	1480	1055.1	1391.2	998.4
3	219200	715	206048	676
4	30	451	28.2	426.4
∑	220880	3276.2	207627.2	2288

Table 4. Recapitulation of Capacity dan Total Profit of Case 2.

Case	$I_i = I_{i-1}$	$I_i> I_{i-1}$
Total Capacity used	220880	207627.2
Percentage of Total Capacity used	100%	94,02%
Total Profit	3276.2	2288

Comparison between Model Modifikation in Multi Service Multilink Network

Table 5 and Table 6 describe the recapitulation of our results and the results conducting by Puspita et al. (2015) respectively.

Based on the Table 5 and 6, the biggest profit obtained with 4 services and 3 links certainly the biggest solution when we increase the number of services and the links. So basically here, the providers are able to achieve their goals if they extend or design many numer of services and links offered. The case when the base price is set up to be constant means that the provider is able to recover the cost and the quality premium to be varied means that the user can select the service for this case, the user is able to choose the service when $I_i = I_{i-1}$.

If we examine, both Table 5 and 6 only show the result when setting the index quality of $I_i=I_{i-1}$ and $I_i< I_{i-1}$ since other requirement can be solved optimally or in other words cannot achieve the optimal solution.

Table 5. Recapitulation of Capacity and Total Profit for 4 services (*i*) and 3 links (*j*).

i	Case 1 α, β Constant				Case 2 α Constant, $\beta_i = \beta_{i-1}$			
	Link 1				Link 1			
	$I_i = I_{i-1}$		$I_i < I_{i-1}$		$I_i = I_{i-1}$		$I_i < I_{i-1}$	
	Total Capacity	Profit	Total Capacity	Profit	Total Capacity	Profit	Total Capacity	Profit
1	50	153	50	153	50	33	47	31.2
2	170	2295	170	2295	170	495	159.8	468
3	8150	765	7579.5	712.5	8150	165	7661	156
4	10	561	9.3	522.5	10	121	9.4	114.4
	Link 2				Link 2			
1	70	306	70	306	70	66	65,8	62,4
2	750	1071	750	1071	750	230,1	705	218,4
3	132440	1224	123169.2	1140	132440	264	124493.6	249.6
4	10	918	9.3	855	10	198	9.4	187.2
	Link 3				Link 3			
1	50	459	50	459	50	99	47	93.6
2	560	1530	560	1530	560	330	526.4	312
3	78610	1326	73107.3	1235	78610	286	73893.4	270.4
4	10	612	9.3	570	10	132	9.4	124.8
∑	220880	11220	205533.9	10849	220880	3276.2	207627.2	2288

Table 6. Recapitulation of Capacity and Total Profit for 3 services (*i*) and 2 links (*j*).

i	Case 1 α, β Constant				Case 2 α constant, $\beta_i = \beta_{i-1}$			
	Link 1				Link 1			
	$I_i = I_{i-1}$		$I_i < I_{i-1}$		$I_i = I_{i-1}$		$I_i < I_{i-1}$	
	Total Capacity	Profit	Total Capacity	Profit	Total Capacity	Profit	Total Capacity	Profit
1	210	15.105	50	153	210	23,5	600	39
2	2625	226.575	170	2295	2625	351	3375	387
3	1155	75.525	7579.5	712.5	1155	117	0	75
	Link 2				Link 2			
1	600	30.6	70	30,6	210	46,8	210	46.8
2	3375	282.52	750	282.52	2625	436.8	2625	436.8
3	0	120	123169.2	120	1155	187.2	1155	187.2
∑	7965	750.325	7950	750.445	7980	1162.2	7965	1171.8

CONCLUSION

From the results, it can be concluded that genralized models have difference solutions that depends on the number services and links offered. In multi service network generate optimal solution at case 1 α and β constant for $I_i = I_{i-1}$ with total revenue 11022 unit price (per kbps) while in case 2 (α constant and β variable) for $I_i < I_{i-1}$ with total revenue 3276.2 unit price (per kbps).

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