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Generalized Models for Internet Pricing Scheme under Multi Class QoS Networks

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ABSTRACT

Background: Nowadays, it is a big challenge for Internet Service Provider (ISPs) to deal with the concise pricing scheme under dynamical situations occurring in internet network to maximize the revenue and serve better network services to the customers. The previous research proposed the single link internet pricing scheme for a limited number of users and classes in multi class QoS networks. **Objective:** To generalize the model of internet pricing in multi class QoS network into a number of users and classes **Results:** Compared with previous model, the proposed results show that in model by fixing the base price, varying the quality premium, fixing the user's price sensitivity *i* in class *j* and varying the price in class *j* we obtain the maximum revenue of 4,994.64. **Conclusion:** The Generalized improved models for internet pricing model in multi class QoS network with more users and more classes with the base price and quality premium as a constant or a variable by setting up the user i sensitivity in class *j* ($\tilde{W}_{ij}$) and sensitivity in class *j* (W_j) can be solved to obtain the better maximum profit for according to ISP' preferences. The solutions show the connections between $\tilde{W}_{ij}$ and W_j as a parameter or variable in maximizing the revenue. In model 1 modified, the highest maximum revenue in case where $\tilde{W}_{ij}$ as parameter and W_j as variable. Meanwhile, in model 2 modified, the highest revenue is in case where $\tilde{W}_{ij}$ as variable and W_j as parameter. This is due to the Z_{ij} values.

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INTRODUCTION

With the needs to have fast internet, the challenge to provide better quality of internet is essential. The network service quality is determined by the users' satisfactoriness. ISPs have a task to offer better and different QoS to the users to reach the best information quality and also to gain the profit from the available resources. The knowledge to develop the new pricing scheme under user willingness and the providers are provided but only few involve QoS network (Irmeilyana et al., 2014a; Irmeilyana et al., 2014b; Irmeilyana et al., 2014c; Puspita et al., 2011; Puspita et al., 2011; Puspita et al., 2012b; Puspita et al., 2013d).

The latest internet pricing schemes basically comprise three well-known pricing schemes which are flat fee, usage-based, and two-part tariff (Indrawati et al., 2013; Indrawati et al., 2014; Indrawati et al., 2013; Indrawati et al., 2014a; Indrawati et al., 2014b; Wu and Banker, 2010). These three schemes are applied in their discussion under utility function which measures the consumer's satisfactory level. The further optimization of internet pricing schemes are needed in multiservice (Irmeilyana et al., 2013; Irmeilyana et al., 2014a; Puspita et al., 2012a; Puspita et al., 2012c) and multi class QoS networks.

Yang (2004) and Yang et al.(2004; 2004; 2005; 2003) have conducted the research focused on internet pricing on multi class QoS by describing the auction scheme in obtaining the optimal solution. In fact, there exist some parameters affected QoS which can be considered. Based on (Puspita et al., 2013d) by improving and modifying with formulation derived from Yang (2004) and also by considering the utility function

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originally proposed by Wu and Banker (2010), base price and quality premium as a constant or a variable, index quality, level of QoS and bandwidth needed, we can propose new improved optimal solution.

The studies focused on the improved models for internet pricing scheme in single bottleneck link under multi service network have been proposed (Irmeilyana et al., 2013; Irmeilyana et al., 2014b; Puspita et al. 2012a; Puspita et al. 2012c) and under multi class QoS network (Irmeilyana et al., 2014a; Irmeilyana et al., 2014b; Irmeilyana et al., 2014c; Puspita et al. 2011; Puspita et al. 2011; Puspita et al. 2012b; Puspita et al. 2013a; Puspita et al. 2013d); the improved models in multi bottleneck links (Puspita et al. 2014; Puspita et al. 2013a; Puspita et al. 2013b; Puspita et al. 2013c).. Those studies conducted by setting up the base price and quality premium as a constant or a variable, setting up the QoS level to obtain better maximum profit than previously method described. Those models are applied to two users and classes in multi class QoS networks. In fact, in improving the quality, ISP provides more services and more classes to more users.

This paper basically attempts to offer the generalized optimal solution by applying the improved models for internet pricing in single link with more classes based on Puspita et al. (2014; 2013d) models. The results obtained can assist ISP to choose the best pricing scheme satisfying the users.

Research Method:

In this paper, we will solve the optimization problem by using LINGO 11.0. We have 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.

Improved Models:

Models used are adapted from Puspita et al. (2013d) model by distinguishing the model according to the price sensitivity for user i in class j ($\widetilde{W}_{ij}$) and sensitivity in class j (W_j). We divide into six models namely model 1 original, model 1 modified 1 with α dan β as a constant, model 1 modified 2 with α as a constant and β as variable, model 2 original, model 2 modified 1 with α as variable and β as a constant and model 2 modified 2 with α dan β as variable

The modified models are divided into three namely

i) If $\widetilde{W}_{ij}$ as parameter and W_j as variable, then we add the constraint as follows.

$$\widetilde{W}_{ij} = k. \tag{1}$$

ii) If $\widetilde{W}_{ij}$ as variable and W_j as parameter, then we add the constraint as follows.

$$W_j = l. \tag{2}$$

iii) If $\widetilde{W}_{ij}$ as parameter and W_j as parameter, then add the constraints (1) dan (2).

RESULTS AND DISCUSSION

The problem of internet pricing scheme can be solved by using the same model proposed by (Puspita et al., 2013d) with the parameter values are fixed to be $\alpha_1 = 0.3$, $\alpha_2 = 0.4$ and $\alpha_3 = 0.5$ when α_j is as a constant and β_1=0.01, β_2=0.05 and β_3=0.1 when β_j is as a constant. The values of V_i for each model in multi class QoS network are V_1=117.09; V_2=8,737.61 and V_3=160.71. We also set Q value of 30,720 for each class. Other parameters are presented in Table 1.

Table 1: Parameter Values in Multi Class QoS Networks.

Parameter	Class (j)		
	1	2	3
c_j	4	5	6
d_j	0.8	0.9	1
f	0.01	0.01	0.01
g	0.5	0.5	0.5
a	0	0	0
b	1	1	1

Tabel 2: Decision Variable Values of Model 1 Original and Model 1 Modified 1.

Variable	Model 1 *Original*	Model 1 Modifikasi 1		
		$\widetilde{W}_{ij}$ Par W_j Var	$\widetilde{W}_{ij}$ Var W_j Par	$\widetilde{W}_{ij}$ Par W_j Par
Z_{11}	0	0	1	1
Z_{12}	0	0	1	1
Z_{13}	0	0	1	0
Z_{21}	1	1	1	1
Z_{22}	1	1	1	1
Z_{23}	1	1	1	1

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Z_{31}	1	1	1	1
Z_{32}	1	1	1	1
Z_{33}	1	1	1	1
$\widetilde{W}_{11}$	4	5	4	5
$\widetilde{W}_{12}$	4	5	5	5
$\widetilde{W}_{13}$	4	5	6	5
$\widetilde{W}_{21}$	5	6	4	6
$\widetilde{W}_{22}$	5	6	5	6
$\widetilde{W}_{23}$	5	6	6	6
$\widetilde{W}_{31}$	6	7	4	7
$\widetilde{W}_{32}$	6	7	5	7
$\widetilde{W}_{33}$	6	7	6	7
X_1	10240	10240	10240	10240
X_2	10240.17	10240.17	10240	10240

Tabel 3: Decision Variable Values of Model 1 Original and Model 1 Modified 1(cont'd).

Variabel	Model 1 *Original*	Model 1 Modifikasi 1		
		$\widetilde{W}_{ij}$ Par W_j Var	$\widetilde{W}_{ij}$ Var W_j Par	$\widetilde{W}_{ij}$ Par W_j Par
X_3	10240.17	10240.17	10240	10240
L_{m1}	0	0	0	0
L_{m2}	0	0	0	0
L_{m3}	0	0	0	0
I_1	-	0.8	0.8	0.8
I_2	-	0.9	0.9	0.9
I_3	-	1	1	1
$\hat{X}_{11}$	10240	10240	10240	10240
$\hat{X}_{12}$	10239.67	10239.67	10240	10240
$\hat{X}_{13}$	10239.67	10239.67	10240	10239.33
$\hat{X}_{21}$	10240	10240	10240	10240
$\hat{X}_{22}$	10240.17	10240.17	10240	10240
$\hat{X}_{23}$	10240.17	10240.17	10240	10240.33
$\hat{X}_{31}$	10240	10240	10240	10240
$\hat{X}_{32}$	10240.17	10240.17	10240	10240
$\hat{X}_{33}$	10240.17	10240.17	10240	10240.33
W_1	5	6	4	4
W_2	5	6	5	5
W_3	5	6	6	6

Table 2 shows the comparison of variable values of model 1 original and model 1 modified 1 for each case in achieving the optimal solutions. The value of Z_{ij} represents the user i in class j. If $Z_{ij} = 1$ then the user i in class j. On the other hand, if $Z_{ij} = 0$ then otherwise. According to Table 2 and Table 3 we can see that the decision variable values for each model have quite close values.

Table 4 and 5 explain the comparison of decision variable values of model 1 modified 2 for each case in achieving the optimal solution. We can see that there are same values in each case, and the different value for each case is insignificant. We obtain the highest $\hat{X}_{ij}$ and X_j in model 1 modified 2 for $\widetilde{W}_{ij}$ as parameter and W_j as variable. The optimal solution for model 1 is presented in Table 6.

Table 4: Variable Decision Values of Model 1 Modified 2.

Variable	Model 1 Modified 2		
	$\widetilde{W}_{ij}$ Par W_j Var	$\widetilde{W}_{ij}$ Var W_j Par	$\widetilde{W}_{ij}$ Par W_j Par
β_1	0.5	0.5	0.5
β_2	0.5	0.5	0.5
β_3	0.5	0.5	0.5
Z_{11}	0	1	1
Z_{12}	0	1	1
Z_{13}	0	1	0
Z_{21}	1	1	1
Z_{22}	1	1	1
Z_{23}	1	1	1
Z_{31}	1	1	1
Z_{32}	1	1	1
Z_{33}	1	1	1
$\widetilde{W}_{11}$	5	4	5
$\widetilde{W}_{12}$	5	5	5
$\widetilde{W}_{13}$	5	6	5

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$\widetilde{W}_{21}$	6	4	6
$\widetilde{W}_{22}$	6	5	6
$\widetilde{W}_{23}$	6	6	6
$\widetilde{W}_{31}$	7	4	7
$\widetilde{W}_{32}$	7	5	7
$\widetilde{W}_{33}$	7	6	7
X_1	10,240	10,240	10,240
X_2	10,240.17	10,240	10,240
X_3	10,240.17	10,240	10,240.33
L_{m1}	0	0	0
L_{m_2}	0	0	0

According to the optimal solution presented in Table 6, the maximum profit is achieved in model 1 modified 2 for $\widetilde{W}_{ij}$ as parameter and W_j as variable of Rp. 3,736.64 (per kbps) through 11 iterations.

Table 5: Variable Decision Values of Model 1 Modified 2(cont'd).

Variable	Model 1 Modified 2		
	$\widetilde{W}_{ij}$ Par W_j Var	$\widetilde{W}_{ij}$ Var W_j Par	$\widetilde{W}_{ij}$ Par W_j Par
L_{m3}	0	0	0
I_1	0.8	0.8	0.8
I_2	0.9	0.9	0.9
I_3	1	1	1
$\hat{X}_{11}$	10,240	10,240	10,240
$\hat{X}_{12}$	10,239.67	10,240	10,240
$\hat{X}_{13}$	10,239.67	10,240	10,239.33
$\hat{X}_{21}$	10,240	10,240	10,240
$\hat{X}_{22}$	10,240.17	10,240	10,240
$\hat{X}_{23}$	10,240.17	10,240	10,240.33
$\hat{X}_{31}$	10,240	10,240	10,240
$\hat{X}_{32}$	10,240.17	10,240	10,240
$\hat{X}_{33}$	10,240.17	10,240	10,240.33
W_1	6	4	4
W_2	6	5	5
W_3	6	6	6

Tabel 6: Model 1 Optimal Solution.

Solver Status	Model 1 *Original*	Model 1 Modified 1			Model 1 Modified 2		
		$\widetilde{W}_{ij}$ Par W_j Var	$\widetilde{W}_{ij}$ Var W_j Par	$\widetilde{W}_{ij}$ Par W_j Par	$\widetilde{W}_{ij}$ Par W_j Var	$\widetilde{W}_{ij}$ Var W_j Par	$\widetilde{W}_{ij}$ Par W_j Par
Model Class	INLP						
State	Local optimal						
Infeasibility	$3{,}64 \cdot 10^{-12}$	0	$3{,}64 \cdot 10^{-12}$	$3{,}64 \cdot 10^{-12}$	0	0	$3{,}64 \cdot 10^{-12}$
Iterations	5	5	21	4	11	11	11
Extended Solver state							
Solver type	Branch & Bound						
Best Objective	3110.89	3733.05	3111.65	3112.05	3736.64	3116.14	3115.64
Objective bound	3110.89	3733.05	3111.65	3112.05	3736.64	3116.14	3115.64
Active	0	0	0	0	0	0	0
Update interval	2	2	2	2	2	2	2
GMU(K)	34	36	34	37	38	36	38
ER(sec)	0	0	0	0	0	0	0

Table 5 presents the comparison of decision variable values of model 2 original and modified 2 for each case in achieving the optimal solutions. In fact, all have very close values. The final bandwidth achieved by user i in class j ($\hat{X}_{ij}$) and bandwidth value for each user in class j (X_j) of model 2 original is the same as model 2 modified 1 with $\widetilde{W}_{ij}$ as parameter and W_j as variable. If we attempt to compare model 2 modified 1 for $\widetilde{W}_{ij}$ as variable and W_j as parameter with $\widetilde{W}_{ij}$ as parameter and W_j as parameter then we have insignificant difference for those models.

Table 7a and 7b explains the decision variable comparison obtained in model 2 modified 2 for each case in obtaining the optimal solution. We can see that some values are the same for each case and some have every close values for each case.

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Table 7a: The Decision Variable Values of Model 2 *Original* and Model 2 Modified1.

Variable	Model 2 *Original*	Model 2 Modified 1		
		$\widetilde{W}_{ij}$ Par W_j Var	$\widetilde{W}_{ij}$ Var W_j Par	$\widetilde{W}_{ij}$ Par W_j Par
α_1	1	1	1	1
α_2	1	1	1	1
α_3	1	1	1	1
Z_{11}	0	0	1	1
Z_{12}	0	0	1	1
Z_{13}	0	0	1	0
Z_{21}	1	1	1	1
Z_{22}	1	1	1	1
Z_{23}	1	1	1	1
Z_{31}	1	1	1	1
Z_{32}	1	1	1	1
Z_{33}	1	1	1	1
$\widetilde{W}_{11}$	4	5	4	5
$\widetilde{W}_{12}$	4	5	5	5
$\widetilde{W}_{13}$	4	5	6	5
$\widetilde{W}_{21}$	5	6	4	6
$\widetilde{W}_{22}$	5	6	5	6
$\widetilde{W}_{23}$	5	6	6	6
$\widetilde{W}_{31}$	6	7	4	7
$\widetilde{W}_{32}$	6	7	5	7

Table 7b: The Decision Variable Values of Model 2 *Original* and Model 2 Modified1 (Cont'd).

Variable	Model 2 *Original*	Model 2 Modified 1		
		$\widetilde{W}_{ij}$ Par W_j Var	$\widetilde{W}_{ij}$ Var W_j Par	$\widetilde{W}_{ij}$ Par W_j Par
$\widetilde{W}_{33}$	6	7	6	7
X_1	10.240,33	10.240,33	10.240	10.240
X_2	10.240,33	10.240,33	10.240	10.240
X_3	10.240,33	10.240,33	10.240	10.240,33
L_{m1}	0	0	0	0
L_{m2}	0	0	0	0
L_{m3}	0	0	0	0
I_1	0,8	0,8	0,8	0,8
I_2	0,9	0,9	0,2	0,9
I_3	1	1	1	1
$\hat{X}_{11}$	10,239.33	10,240.33	10,240	10,240
$\hat{X}_{12}$	10,239.33	10,240.33	10,240	10,240
$\hat{X}_{13}$	10,240.33	10,240.33	10,240	10,239.33
$\hat{X}_{21}$	10,240.33	10,240.33	10,240	10,240
$\hat{X}_{22}$	10,240.33	10,240.33	10,240	10,240
$\hat{X}_{23}$	10,240.33	10,240.33	10,240	10,240.33
$\hat{X}_{31}$	10,240.33	10,240.33	10,240	10,240
$\hat{X}_{32}$	10,240.33	10,240.33	10,240	10,240
$\hat{X}_{33}$	10,240.33	10,240.33	10,240	10,240.33
W_1	5	6	4	4
W_2	5	6	5	5
W_3	5	6	6	6

Table 8a: Decision Variable Values of Model 2 Modified 2.

Variable	Model 2 Modified2		
	$\widetilde{W}_{ij}$ Par W_j Var	$\widetilde{W}_{ij}$ Var W_j Par	$\widetilde{W}_{ij}$ Par W_j Par
α_1	1	1	1
α_2	1	1	1
α_3	1	1	1
β_1	0.5	0.5	0.5
β_2	0.5	0.5	0.5
β_3	0.5	0.5	0.5
Z_{11}	0	1	1
Z_{12}	0	1	1
Z_{13}	0	1	0
Z_{21}	1	1	1
Z_{22}	1	1	1
Z_{23}	1	1	1
Z_{31}	1	1	1
Z_{32}	1	1	1

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Z_{33}	1	1	1
$\widetilde{W}_{11}$	5	4	5
$\widetilde{W}_{12}$	5	5	5
$\widetilde{W}_{13}$	5	6	5
$\widetilde{W}_{21}$	6	4	6
$\widetilde{W}_{22}$	6	5	6
$\widetilde{W}_{23}$	6	6	6

Table 8b: Decision Variable Values of Model 2 Modified 2(cont'd).

Variable	Model 2 Modified2		
	$\widetilde{W}_{ij}$ Par W_j Var	$\widetilde{W}_{ij}$ Var W_j Par	$\widetilde{W}_{ij}$ Par W_j Par
$\widetilde{W}_{31}$	7	4	7
$\widetilde{W}_{32}$	7	5	7
$\widetilde{W}_{33}$	7	6	7
X_1	10,240.33	10,240	10,240
X_2	10,240.33	10,240	10,240
X_3	10,240.33	10,240	10,240.33
L_{m1}	0	0	0
L_{m_2}	0	0	0
L_{m3}	0	0	0
I_1	0.8	0.8	0.8
I_2	0.9	0.2	0.9
I_3	1	1	1
$\hat{X}_{11}$	10,240.33	10,240	10,240
$\hat{X}_{12}$	10,240.33	10,240	10,240
$\hat{X}_{13}$	10,240.33	10,240	10,239.33
$\hat{X}_{21}$	10,240.33	10,240	10,240
$\hat{X}_{22}$	10,240.33	10,240	10,240
$\hat{X}_{23}$	10,240.33	10,240	10,240.33
$\hat{X}_{31}$	10,240.33	10,240	10,240
$\hat{X}_{32}$	10,240.33	10,240	10,240
$\hat{X}_{33}$	10,240.33	10,240	10,240.33
W_1	6	4	4
W_2	6	5	5
W_3	6	6	6

Table 9: Optimal Solution of Model 2.

Solver Status	Model 2 *Original*	Model 2 Modified 1			Model 2 Modified 2		
		$\widetilde{W}_{ij}$ Par W_j Var	$\widetilde{W}_{ij}$ Var W_j Par	$\widetilde{W}_{ij}$ Par W_j Par	$\widetilde{W}_{ij}$ Par W_j Var	$\widetilde{W}_{ij}$ Var W_j Par	$\widetilde{W}_{ij}$ Par W_j Par
Infeasibility	$3.64x10^{-12}$	$3.64x10^{-12}$	$8.33x10^{-17}$	0	$3.64x10^{-12}$	$1.89 \cdot x10^{-12}$	$3.64x10^{-12}$
Iterations	8	17	7	7	7	6	7
Best Objective	2,078.33	2,493.1	3,118.11	2,702.38	2,495.49	3,121.54	2,705.57
Objective bound	2,078.33	2,493.1	3,118.11	2,702.38	2,495.49	3,121.54	2,705.57
Active	0	0	0	0	0	0	0
Update interval	2	2	2	2	2	2	2
GMU(K)	36	38	36	38	40	38	40
ER(sec)	0	0	0	0	0	0	0

According to optimal solution presented in Table 8, we obtain the maximum profit with $\widetilde{W}_{ij}$ as variable and W_j as parameter in model 2 modified 2 of Rp. 3,121.54 (per kbps) which is solved by 6 iterations as stated in Table 9.

Table 10: Recapitulation of Optimal Solution Model in Multi Class QoS.

Solver Status	Model 1 Modified 2	Model 2 Modified 2
	$\widetilde{W}_{ij}$ Par W_j Var	$\widetilde{W}_{ij}$ Var W_j Par
Model Class	*INLP*	
State	*Local optimal*	
Infeasibility	0	$1.89x10^{-12}$
Iterations	11	6
Extended Solver Status		
Solver type	*Branch & Bound*	
Best Objective	3736.64	3121.54
Objective bound	3736.64	3121.54
Active	0	0
Update interval	2	2

GMU(K)	38	38
ER(sec)	0	0

The results in Table 10 explain the comparison of highest optimal solutions in every model 1 and Model 2 in multi class QoS networks previously described in Table 4 and Table 7a and 7b. The maximum solution is obtained in Model 1 of modification 2 for $\widetilde{W}_{ij}$ as parameter and W_j as variable with maximum profit of Rp. 3,736.64 (per kbps).

Conclusion:

The Generalized improved models for internet pricing model in multi class QoS network with more users and more classes with the base price and quality premium as a constant or a variable by setting up the user i sensitivity in class j ($\widetilde{W}_{ij}$) and sensitivity in class j (W_j) can be solved to obtain the better maximum profit for according to ISP' preferences. The solutions show the connections between $\widetilde{W}_{ij}$ and W_j as a parameter or variable in maximizing the revenue. In model 1 modified, the highest maximum revenue in case where $\widetilde{W}_{ij}$ as parameter and W_j as variable. Meanwhile, in model 2 modified, the highest revenue is in case where $\widetilde{W}_{ij}$ as variable and W_j as parameter. This is due to the Z_{ij} values.

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