The New Improved Models of Single Link Internet Pricing Scheme in Multiple QoS Network

Irmeilyana, Indrawati, Fitri Maya Puspita, and Lisma Herdayana

Abstract— In this paper, the new improved internet pricing scheme in multiple Qos networks will be presented. The new pricing scheme is the improved and modified from previous research. The new improved model is proposed to obtain better solution than previous results conducted by previous research. ISPs need a new pricing scheme to maximize the revenue and provide better services to customers. The models are set up by fixing the fixed base price, by varying the quality premium and user' sensitivity price. The model is considered as Mixed Integer Nonlinear Programming (MINLP) and that can be solved by LINGO 11.0 to obtain the optimal solutions. The results show that by improving the pricing scheme model, the user' sensitivity price in certain services will yield maximum profit for ISPs.

Keywords— Multiple QoS network, pricing scheme, base price, quality premium.

I. Introduction

PREVIOUS works on pricing scheme of QoS networks is due to [1-3]. They described the pricing scheme based auction to allocate QoS and maximize ISP's revenue. The solution of the optimization problem goes from single bottleneck link in the network and then they generalized into multiple bottleneck links using heuristic method. In their study, they used single QoS parameter-bandwidth. They basically formulate pricing strategy for differentiated QoS networks. In their discussion, they focus on auction algorithm to find the optimal solution. Based on their idea, it is attempted to improve and modify their mathematical formulation and combine it with mathematical formulation discussed by Byun and Chatterjee [4] (see in [5-11]).

Recent studies have also been conducted to address problem of multiple service network, other kind of pricing scheme in network. Sain and Herpers [12] discussed problem of pricing in multiple service networks. They solve the internet pricing by transforming the model into optimization model and solved using Cplex software. Also, [13, 14] discussed the new approach and new improved model of [4, 12] and got better results in getting profit maximization of ISP.

Although QoS mechanisms are available in some researches, there are few practical QoS network. Even recently a work in this QoS network proposed by [4], it only applies simple network involving one single route from source to destination.

So, the contribution is created by improving the mathematical formulation of [1, 4] to be simpler formulation in single link by taking into consideration the utility function, base price as fixed price or variable, quality premium as fixed prices and variable, index performance, capacity in one link and also bandwidth required (see [5, 11]). The problem of internet charging scheme is considered as Mixed Integer Nonlinear Programming (MINLP) to obtain optimal solution by using LINGO 13.0 [15] software. 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. This study focuses to vary the quality premium parameters and see what decision can be made by ISP by choosing this parameter.

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

We consider cases of α, base price to be fixed and or β, the quality premium to be fixed or vary depends on what target ISP would achieve. The Objective of ISP is also to obtain maximized.

II. Methodology

Steps involving in this paper are as follows.

1. Determine the variables and decision parameters
2. Determine the constraints in each cases by considering to fix base price, to fix and vary quality premium and user's sensitivity price.
3. Formulate the MINLP models based on the determined parameters and constraints

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4. Formulate each cases by setting up to fix base price, to fix and vary quality premium and user's sensitivity price.
5. Solve the MINLP models by using LINGO 11.0
6. Analyze the results and conclude.

III. Results And Discussion

First, for obtaining the solution of the pricing scheme model, we set up the parameters and the decision variables presented in Table 1 and Table 2, respectively.

TABLE I
PARAMETERS FOR PRICING MODEL

Parameters when α_j and β_j fixed	
Q	: Total bandwidth
V_i	: Minimum bandwidth required by user i
β_j	: Quality premium of class j that has I_j service performance
c_j	: Predetermined value of upper bound price sensitivity for user i at class j
d_j	: Maximum quality index value in class j
Parameters when α_j fixed and β_j vary	
α_j	: Base price for class j
Q	: Total bandwidth
V_i	: Minimum bandwidth required by user i
c_j	: Predetermined value of upper bound price sensitivity for user i at class j
d_j	: Maximum quality index value in class j
f_j	: Minimum quality premium value for class j
g_j	: Maximum quality premium value for class j

TABLE II
DECISION VARIABLES FOR PRICING MODEL

Decision variables when α_j and β_j fixed	
Z_{ij}	$= \begin{cases} 1, & \text{if user } i \text{ is admitted to class } j \\ 0, & \text{otherwise} \end{cases}$
$\hat{X}_{ij}$	: Final bandwidth obtained by user i for class j
L_{m_j}	: Minimum bandwidth for class j
W_j	: Price sensitivity for class j
X_j	: Bandwidth assigned to each individual user in class j
$\tilde{W}_{ij}$	: Price sensitivity for user i in class j
I_j	: Quality index of class j
Decision variables when α_j fixed and β_j vary	
Z_{ij}	$= \begin{cases} 1, & \text{if user } i \text{ is admitted to class } j \\ 0, & \text{otherwise} \end{cases}$
$\hat{X}_{ij}$	: Final bandwidth obtained by user i for class j
L_{m_j}	: Minimum bandwidth for class j
W_j	: Price sensitivity for class j
X_j	: Bandwidth assigned to each individual user in class j
$\tilde{W}_{ij}$	: Price sensitivity for user i in class j
I_j	: Quality index of class j
β_j	: Quality premium for class j

The pricing scheme models is already discussed in [5], so here we compare the original model proposed by [1] and improved by [5] with our improved model and our data from local server then we have solver status of three models with model 1 original of [1] and improved models of [5-8] with modification on the price sensitivity of user i in class j to be fixed price and price sensitivity for class j as variables to let the ISPs to decide how much the willingness to pay for the ISP spent for each class.

Table III and Table IV explain the solver status of the three models; original, modified with beta fixed and modified with beta vary. From our data, we have minimum bandwidth of user i =1 and 2 are V_1=19418.96357 for traffic of files and V_1=400.3464254 for traffic of web in local server .

TABLE III
SOLVER STATUS OF MODEL 1 UNTUK V_1=19418.96357 dan Q=30720

Solver status	Original	Modified (beta fixed)	Modified (beta vary)
Model Class	MINLP	MINLP	MINPL
State	Local optimal	Local optimal	Local optimal
Infeasibility	0	0	0
Extended Solver state			
Solver type	B & B	B & B	B & B
Active	0	0	0
Update interval	2	2	2
GMU(K)	28	29	30
ER(sec)	0	0	0
Best Objective	1	1.05	1.12
Objective bound	1	1.05	1.12
ESS	0	0	0
TSI	4	4	4

In Table III, Generated Memory Used (GMU) shows that how much memory allocation that LINGO used to solve the model. The highest GMU is obtained in modifying the beta to vary of 30 K. Elapsed Runtime (ER) shows that the total time used to obtain and solve the models. It has effect on the number of other running application in the system. In each case, the ER is 0 sec. Extended Solver Steps depends on the certain solver that is running in the system. All models used branch and bound solver. The best model to be adopted is model with modifying the beta to be varied, since the MINLP achieves highest maximum value.

TABLE IV
SOLVER STATUS OF MODEL 1 FOR V_1 = 400.3464254 DAN Q=30720

Solver status	Original	Modified (beta fixed)	Modified (beta vary)
Model Class	INLP	INLP	INPL
State	Local optimal	Local optimal	Local optimal
Infeasibility	0	0	0
Extended Solver state			
Solver type	B & B	B & B	B & B
Active	0	0	0
Update interval	2	2	2
GMU(K)	28	29	30
ER(sec)	1	0	0
Best Objective	1	1.05	1.12
Objective bound	1	1.05	1.12
ESS	0	0	0
TSI	4	4	4

The highest GMU of 30K is when we have the modified with beta varies as shown in Table IV. ER= 0 sec in each case. Since all model has branch and bound solver, then ESS=0.

TABLE V
OPTIMAL SOLUTIONS MODEL 1 FOR V_1=19418.96357 DAN Q=30720

	Original	Modified (beta fixed)	Modified (β vary)
α_1	0.2 fixed	0.2 fixed	0.2 fixed
Z_{11}	1	1	1
W_1	1.234568	0	0
$\ddot{X}_{11}$	1.234568	1	1
L_1	1.234568	0.100000E-01	0.100000E-01
Z_{21}	1	1	1
$\ddot{X}_{21}$	1.234568	1	1
α_2	0.3 fixed	0.3 fixed	0.3 fixed
Z_{12}	1	1	1
W_2	1.234568	0	0
$\ddot{X}_{12}$	1.234568	1	1
L_2	1.234568	0.100000E-01	0.100000E-01
Z_{22}	1	1	1
$\ddot{X}_{22}$	1.234568	1	1
X_1	1.234568	1	1
X_2	1.234568	1	1
β_1	-	0.1000000E-01	0.4000000E-01
β_2	-	0.2000000E-01	0.3000000E-01
I_1	-	0.9	0.9
I_2	-	0.8	0.8

Table V shows the values of decision variables in three cases which are original, modified with beta is fixed and modified with beta varies. The sensitivity price for class j (w_j) is 1.2 for each class; Each user are allowed in each class. Bandwidth for each user i is 1.2 in each class where the bandwidth for class j has the same value ith bandwidth for user i which is 1.2.

TABLE VI
SOLVER STATUS DARI MODEL 1 FOR V_2 = 400.3464254 DAN Q=30720

	Original	Modified (β fixed)	Modified (β varies)
α_1	0.2 fixed	0.2 fixed	0.2 fixed
Z_{11}	1	1	1
W_1	1.234568	0	0
$\ddot{X}_{11}$	1.234568	1	1
L_1	1.234568	0.100000E-01	0.100000E-01
Z_{21}	1	1	1
$\ddot{X}_{21}$	1.234568	1	1
α_2	0.3 fixed	0.3 fixed	0.3 fixed
Z_{12}	1	1	1
W_2	1.234568	0	0
$\ddot{X}_{12}$	1.234568	1	1
L_2	1.234568	0.100000E-01	0.100000E-01
Z_{22}	1	1	1
$\ddot{X}_{22}$	1.234568	1	1
X_1	1.234568	1	1
X_2	1.234568	1	1
β_1	-	0.1000000E-01	0.4000000E-01
β_2	-	0.2000000E-01	0.3000000E-01
I_1	-	0.9	0.9
I_2	-	0.8	0.8

Table VI explains the values of decision variables in three cases which are original, modified with beta is fixed and modified with beta varies. The sensitivity price for class j (w_j) is 1.2 for each class; Each user are allowed in each class. Bandwidth for each user i is 1.2 in each class where the bandwidth for class j has the same value ith bandwidth for user i which is 1.2.

From the variables decision values, we can see that for all cases of bandwidth for files traffic or web traffic, we obtain the highest maximum profit when we set up the model with base price to be fixed and quality premium to be varied. It allows the ISPs to recover cost, by fixing the base price and ISPs is also able to promote certain services to consumers. By varying the quality premium, ISPs is able to promote other services in other class, for example, in class 2 to be applied to other users.

IV. CONCLUSION

From the results, we can see that ISP can adopt the model with modifying quality premium to be varies of 1.2. It means that ISPs can obtain highest profit by considering base price to be fixed to recover cost and beta to be varied to enable ISPs to promote certain service.

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