PROCEEDINGS

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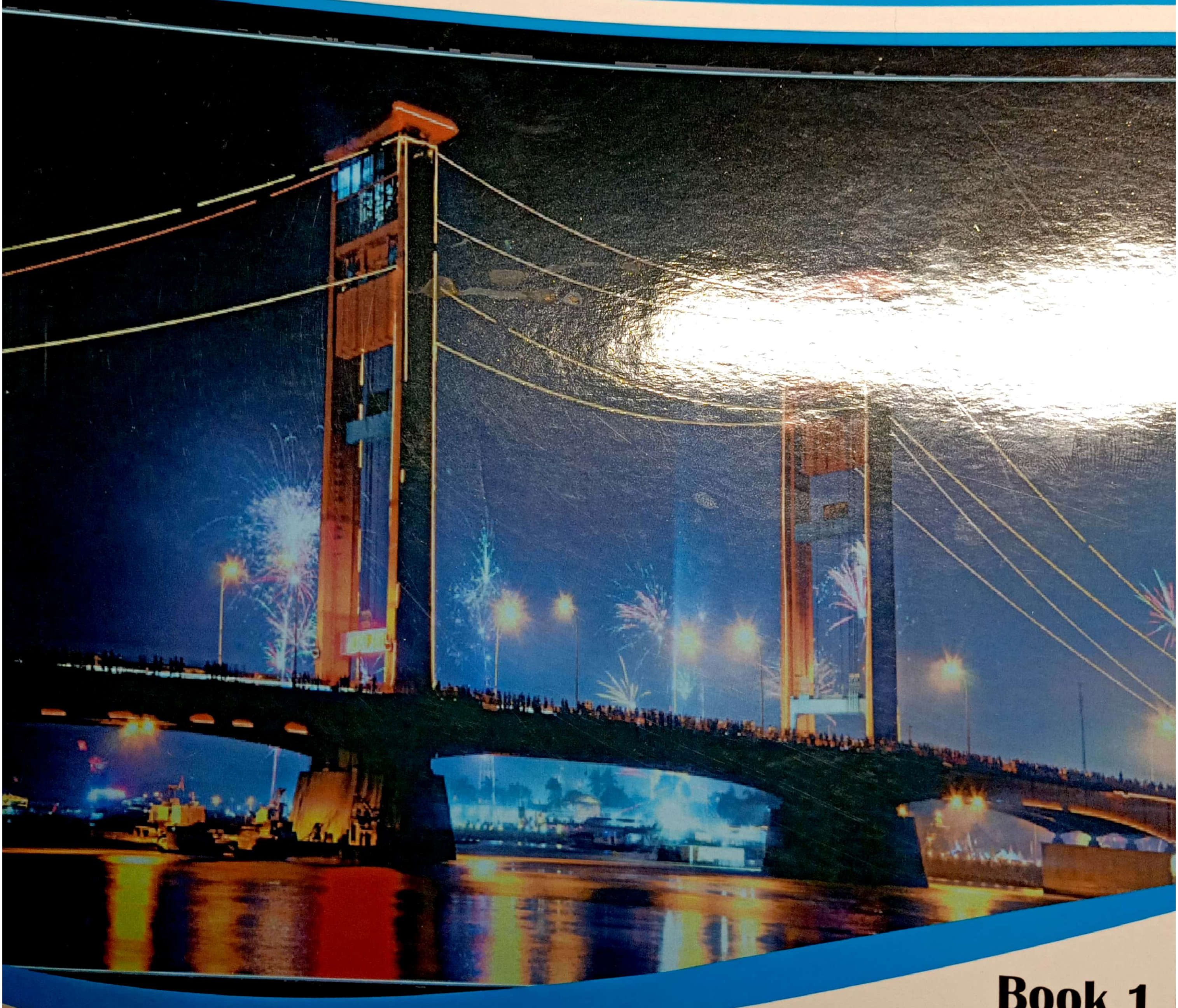

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## CONTENTS

# Improved Models of Wireless Pricing Scheme in Multiple Class QoS Networks by Determining the Base Price Value

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**Abstract.** This paper aims to determine the improved pricing scheme in wireless networks that can provide the maximum benefit for service providers Internet (ISP) that works in multiple class Quality of Service (QoS) network, which can guarantee a given scheme the satisfaction of consumer service providers and service users. Previous research focusing also on multi class QoS network by fixing the base price shows that by varying the quality premium then, the ISP can gain profit. So, we attempt to improve the models by varying the value of base price. The model used will be transformed into a model optimization which will then be examined by considering as a nonlinear programming problem that can solved using LINGO 13.0. The solutions of the models then are compared to original model proposed by previous research to obtain best results. Of the three models discussed, based on the results of each case, the ISP will get maximum benefit when applying the modified model by varying the base price and quality premium.

**Keywords:** improved pricing scheme, benefit, multiple class QoS network

## 1 Introduction

Therefore internet service providers (ISPs) compete in determining the pricing model of wireless internet that can maximize profits, but with the quality of its Internet services. Research on wireless financing scheme of nonlinear modeling are ever conducted by [1-3]. The pricing model of wireless network then carried out using mathematical methods programming [4, 5] and improved by fixing the base price [6, 7]. The wireless pricing models of multiple Class QoS networks utilize the bandwidth and end-to-end delay of QoS attributes and use the improved models in multi class QoS networks [8].

However, the pricing scheme of wireless networks in multiple class QoS network is not limited only to have the base price value to be fixed to recover cost. That goal can be extended to promote certain services offered by ISP while the end users can select the services of their preferences.

Therefore, by collecting all results previously conducted, we attempt to extend the research into multiple Class QoS network by considering the base price value to be determined by ISP to gain certain goals set up by ISP since the profit is also intended to be achieved not only by recovering the cost but also by competing in the market.

Then, the main contribution is to improve the models of wireless in multiple class QoS networks by determining the value of base price to achieve the goal of competing in the market while promoting certain services. Two models are improved by using each QoS attribute. The models obtained are also compared with the original one to show the best results. The proposed models then are transformed into nonlinear programming models and to be solved by LINGO 13.0. With this improved models, the ISP is able to improve the model original by utilizing the total base cost and quality premium as well as utilize the utility function that determines the sensitivity of the user in selecting the appropriate service with a budget that users have.

## 2 Methodology

In this study, the internet pricing scheme used the model proposed [2] The model will then be modified with the model previously proposed by [9] and improved model of [8, 10] in the objective function and constraint functions as a starting measure in determining the basic QoS, and with pay attention to the premium quality of each class to be fixed or varied. The models formed are based on two assumptions where the first assumption that the base price in the form of variable and premium quality is also constant, and assuming both QoS basic price and quality premium are in the form of variable. Model established will then be processed using the data have been obtained from one server local in Palembang, where the data used consisted of the mail and traffic data traffic which will then be solved using LINGO 13.0 to obtain the optimal solution.

## 4 Results and Discussion

The model used in this study is originally from [2] which is then modified by model drawn up [6] for QoS bandwidth. So that the resulting model is to maximize

$$\sum_{j}^{m}\sum_{i}^{n}(PR_{ij} \pm PQ_{ij} + (\alpha_j + W_j\, log\,\frac{\tilde{X}_{ij}}{L_{m_j}})Z_{ij} \quad (1)$$

with some attentions to some important aspects that can affect the optimum result in the form of quality premium of users who have the service performance $I_i$. then the model (1) for the objective function is a modified model to maximize

$$\sum_{j}^{m}\sum_{i}^{n}(PR_{ij} \pm PQ_{ij} + (\alpha_j + \beta_j I_j + W_j\, log\, \frac{\tilde{X}_{ij}}{L_{m_j}})Z_{ij} \quad \textbf{(2)}$$

It means that in order to maximize the total amount consists of the cost to connect with QoS available ($PR_{ij}$), changes in the cost of all the changes in QoS ($PQ_{ij}$), and the formulation of financing models in the internet multi class QoS network proposed by where $\alpha$ is the base price for each class $j$, $\beta$ is a premium quality of $i$ users who have $I_i$ service performance. The set of constraints play a role as limiting the objective function that must be met in the goal of obtaining optimal results. The first constraint states that a change fee depend on the cost factor on bandwidth QoS attributes, the basic cost to the user $i$ and $j$ class, as well as linearity factors By collecting all the information obtained the following constraints.

$$PQ_{ij} = \left(1 \pm \frac{x}{Q_{bij}}\right) PB_{ij} Lx \quad \textbf{(3)}$$

with $Q_{bij}$ is the nominal value of the QoS attributes network operator. In this case the QoS attributes to be measured is bandwidth, where the maximum value for the bandwidth is 2Mbps. $PB_{ij}$ a basic fee for a connection with the user $i$ and class $j$, and $Lx$ is linearity factor. Defining $PB_{ij}$ namely:

$$PB_{ij} = a_{ij}(e - e^{-xB})T_l/100 \quad \textbf{(4)}$$

$a_{ij}$ define linear cost factor in user $i$ and $j$ class, the linear factor ($e$-$e^{-xb}$), and $T_l$ is the traffic load.

$$L_x = a(e - e^{-xB}) \quad \textbf{(5)}$$

$$f \leq a_{ij} \leq g \quad \textbf{(6)}$$

$$h \leq t_l \leq k \quad \textbf{(7)}$$

$$0 \leq x \leq 1 \quad \textbf{(8)}$$

$$0.8 \leq B \leq 1.07 \quad \textbf{(9)}$$

$$a = 1 \quad \textbf{(10)}$$

*Lx* is a factor that depends on the linearity parameters and ($e\text{-}e^{-xb}$), assuming $0 \leq x \leq 1$. The linear factor $a_{ij}$ is limited by the service provider, assume as *f* and *g*. Allowable traffic load $T_l$ is also determined by the service provider, say *h* and *k*. At the constraints (7), x is increment of QoS, which is set between 0 and 1 suggests implicitly that if 0 means to be in conditions best effort and 1 in a state of perfect service. Value B is set to be between 0.8 and 1.07, because in this range the best quality services occur. A linear parameter value is to be determined, with
factor a base rate set. Then, constraints continued with constraints improved [8] as follows.

$$\sum_{j=1}^{2}\sum_{i} X_{ij} \leq Q , i = 1,2 \tag{11}$$

With *Q* is total *bandwith* of 100MBps atau sebesar 102400 Kbps.

$$X_{ij} \geq L_{m_j} - \left(1 - Z_{ij}\right), i = 1,2;\ j = 1,2 \tag{12}$$

$$W_j \leq W_{ij} + \left(1 - Z_{ij}\right), i = 1,2;\ j = 1,2 \tag{13}$$

$$X_{ij} \geq V_i - \left(1 - Z_{ij}\right), i = 1,2;\ j = 1,2 \tag{14}$$

$W_{ij}$ is the sensitifity price for user *i* in class *j*. $V_i$ is minimum bandwith for each user with $V_1$ = 6 Kbps for user 1 and $V_2$ = 5 Kbps for user 2.

.

$$X_{ij} \geq X_j - \left(1 - Z_{ij}\right), i = 1,2;\ j = 1,2 \tag{15}$$

$$X_{ij} \geq Z_{ij} , i = 1,2;\ j = 1,2 \tag{16}$$

$$X_{ij} \geq 0 , i = 1,2;\ j = 1,2 \tag{17}$$

$$L_{m_j} \geq 0.01 , j = 1,2 \tag{18}$$

$$W_j \geq 0 , j = 1,2 \tag{19}$$

$$X_{ij} \leq X_j, i = 1,2;\ j = 1,2 \tag{20}$$

$$Z_{ij} = \begin{cases} 1, & \text{user } i \text{ is admitted to class } j \\ & 0, \text{otherwise} \end{cases} \tag{21}$$

For $\beta_j$ fix, we add the additional constraits as follows.

$$m_j \leq I_j \leq 1;\ j \in [0,1] \tag{22}$$

$$I_j = I_{j-1};\ j = 1,2 \tag{23}$$

$$\beta_1 = 0.01, \beta_2 = 0.02 \quad \textbf{(24)}$$

For $\beta_i$ varies, we have Eq.(22)-(23) and the following equations.

$$\beta_j \cdot I_j \geq \beta_{j-1} \cdot I_{j-1};\ j > 1 \quad \textbf{(25)}$$

$$l_j \leq \beta_j \leq b_j \quad \textbf{(26)}$$

With $l_j$ as a minimum value for quality premium of class $j$, and $b_j$ as the maximum value for quality premium of class $j$.

For $\alpha_j$ varies, we set up the equations as follows.

$$\alpha_j \geq \beta_{j-1} \cdot I_{j-1};\ j > 1 \quad \textbf{(25)}$$

$$s_j \leq \alpha_j \leq u_j, [s_j, u_j] \in [0,1] \quad \textbf{(26)}$$

Then, we seek to obtain the optimal solution for each case involving the 2 QoS attributes. Fig. 1, and Fig. 2 show the optimal solutions for each case and comparison to the original model and the number of iterations involved in each model, respectively.

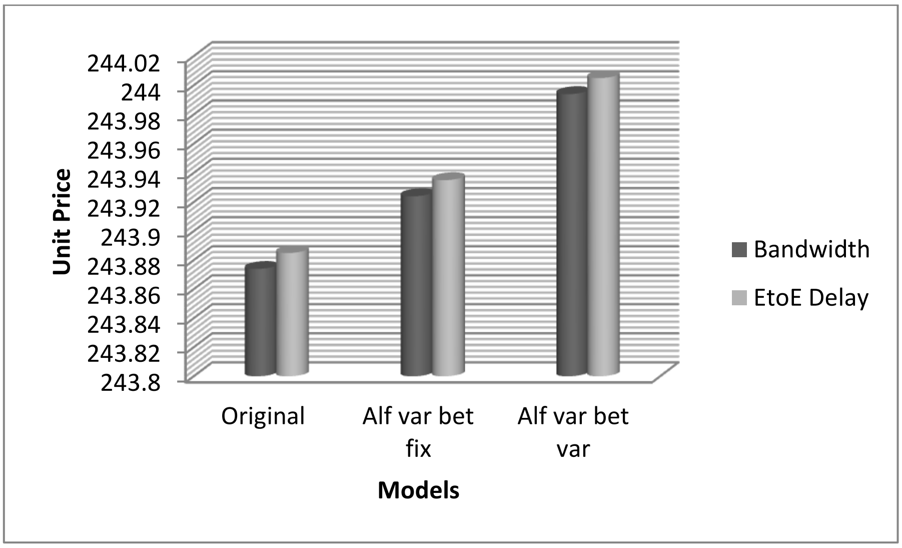


**Fig. 1.** The comparison of the optimal solutions of three models based on the QoS Attributes

From Fig.1, we can see that by varying the base price and the quality premium, the maximum optimal solution can be reached if applying the End-to End Delay attribute. The improved models by varying and fixing the quality premium and varying the base price yield the better optimal solutions with the goals to either promote certain services or users are able to select the class. The End to End delay yield maximum results in model of varying base price and quality premium. This means that the ISP can achieve maximum profit by competing in market and users are able to select the class that are on their preferences

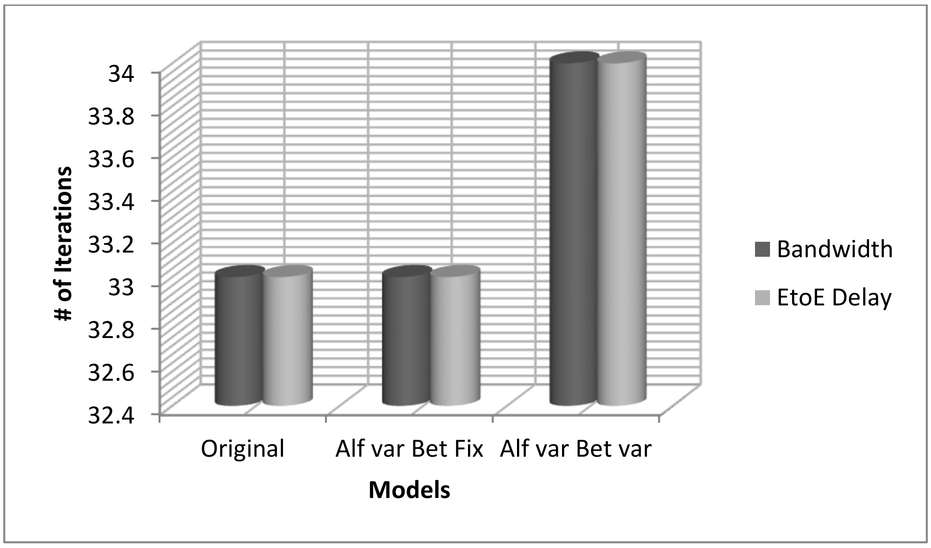


**Fig. 2.** The comparison of the number of iterations need to complete the computation of three models based on the QoS Attributes

Based on Fig. 2, the number of iterations needed to complete the iterations basically is also close for each model with different QoS attribute. It means that, applying the improved models, ISP obtains the maximum profit with the almost same time to complete the models as in original model. Again, for End to End Delay QoS attribute, we have slightly longer time to finish the iterations.

## 6 Conclusion

The objectives of the ISP to achieve the maximum profit when they have the chance to varying the base price to compete in the market is by applying varying the quality premium to enable users to select classes suitable with their budgets. Improved models presented here can show better value in terms of the profit gained and utilize only slightly longer time to finish the iterations.

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