Optimization of Wireless Internet Pricing Scheme in Serving Multi QoS Network Using Various Attributes

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Optimization of Wireless Internet Pricing Scheme in Serving Multi QoS Network Using Various Attributes

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Abstract

Pricing scheme in wireless networks were developed to provide maximum benefit to the internet service provider (ISP), where the given scheme can guarantee customer satisfaction and service providers who use such services. So that the proposed model should be able to attract consumer interest in applying such services. In this research we established wireless pricing model that involve QoS attributes then the model will be transformed into a model of optimization. Pricing models in wireless networks will be studied by looking at existing models as a nonlinear programming problem that can be solved optimally using LINGO 11.0. The solution is to maximize the total price for the connection based on the QoS parameters. Optimal results in the maximizing of pricing scheme is achieved when providers set the increase of price changes due to QoS changes and number of QoS value.

Keywords: *wireless internet pricing, multi QoS network, QoS attribute, optimization*

1. Introduction

In running the business network of the Internet we cannot separate from the discussion on pricing network schemes where the Internet is supposed to provide the best QoS that means providing different networks for certain services [1, 2]. Discussion on the wired pricing Internet of multi services [3-5] and multi-QoS network [6] has been discussed in previous studies. From the discussion we can show that the optimal solution in order to provide benefits to the internet service provider (ISP) is determined via the determination of the cost of basic, premium quality and QoS levels.

The development of the wireless network is very important in business life [7-9] and technology [10, 11]. Huang and Gao approach that it was referred to as optimization problems. Consumers can make a profit by using the discount fee that is considered a model nonlinear [12]. Previous research on the modeling of nonlinear Wireless financing scheme ever undertaken by [13]. Wireless networks are developed to take advantage of the user. Grubb [12] and Wu [14] stated that the financing of two part tariff scheme can improve user satisfaction. The simulation results suggest a link between the cost of elasticity factor user acceptance.

In fact, recent numerous research focused on the wireless pricing are available [15-19]. Only a few research focused on the mathematical modeling of broadband pricing [20] or with complete information on users and utility function [21]. Scarce research examine the wireless pricing through mathematical programming and come up with the optimization problem. Mainly, the research on wireless pricing describe the surveys of methods to charge the 3G/4G pricing , then proceed to simulation method to find the results and lastly analyze the results. However, we attempt to introduce the mathematical modeling of the wireless pricing model of with QoS attributes such as bandwidth, end-to-end delay, and BER (Bit Error Rate) by considering the model of the wireless network as nonlinear programming problems that are solved optimally by using LINGO 11.0. Obtained solution is expected to provide information on the relationship between the factors of acceptance and cost factors that explained mathematically.

Thus, the main contribution of this paper is to provide a mathematical programming involving QoS attribute in wireless network optimization that involves three QoS attributes. The new approach may provide additional information to service providers in adopting a wireless scheme with certain QoS attributes.

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2. Research Method

In this study, the pricing schemes proposed by [13] with QoS attributes such as bandwidth, end-to-end delay, and BER will be improved by adding the original model of [22-24] that consists of the price sensitivity of the users, price sensitivity of the class and also the base price of the class into the objective function and constraint functions. This study used secondary data obtained from one of the local server in Palembang. The data used consist of the data traffic of mail and traffic of digilib. The model will then be solved using LINGO 11.0 to obtain the optimal solution.

3. Model

The main objective of this research is to obtain the maximum benefit for service providers. The approach used is by utilizing the mathematical modeling approach. The model is formed by gathering for information on the parameters and variables.

So the objective function:

$$\text{Max } \sum_j^m \sum_i^n (PR_{ij} \pm PQ_{ij} + \alpha_j Z_{ij} + W_j \log \frac{\tilde{X}_{ij}}{L_{m_j}}) \tag{1}$$

Means that provider wants to maximize the total amount comprises the cost to connect to the available QoS (PR_{ij}), changes in the cost of all the changes in QoS (PQ_{ij}), the utility function measuring the degree of satisfaction of the users, α_j the base price for each class j and decision whether the users i in admitted in class j or not. We also have the sets of constrains as that act as a barrier functions of the objective to be satisfied in the aim of obtaining optimal results.

The first constraint states that a change fee depends on cost factors involving each attribute QoS bandwidth, end-to-end delay, and BER, the base cost with the user i and j class, as well as linearity factors. By collecting all information obtained following constraints.

$$PQ_{ij} = \left(1 \pm \frac{x}{Q_{bij}}\right) PB_{ij} Lx \tag{2}$$

With Q_{bij} as a nominal value of QoS attribute in the operator network. The maximum value for bandwidth is 2Mbps, for end-to-end delay 350kbps, and for BER $10^{-6(atau-7)}$ depending on the type of traffic [13]. PB_{ij} a basic fee for a connection with the user i and class j, and Lx is a linearity factor.

PB_{ij} is defined as:

$$PB_{ij} = a_{ij}(e - e^{-xB})T_l/100 \tag{3}$$

Where a_{ij} is defined as linear price factor in user i and class j, linear factor $(e - e^{-xB})$, and T_l is traffic load.

Lx is a linearity factor depending on parameter a and $(e - e^{-xB})$ then:

$$L_x = a(e - e^{-xB}) \tag{4}$$

With the assumption $0 \le x \le 1$.
Linearity factor a_{ij} lies between the presribed value fixed by the provider, say f and g so:

$$f \le a_{ij} \le g \tag{5}$$

Allowable Traffic load range t_l is also determined by provider, say h and k, then:

$$h \le t_l \le k \tag{6}$$

Where x is the increment of decrement of QoS value that is fixed to be 0 and 1 to implicitly states that 0 is in best effort condition and 1 is a perfect service condition.

Value B is set up between 0.8 and 1.07, since in this range, the best quality of service occurs . Value a is a determined linear parameter with factor a shows the basic level of price.

$$0 \leq x \leq 1 \tag{7}$$

$$0.8 \leq B \leq 1.07 \tag{8}$$

$$a = 1 \tag{9}$$

Next constraint will be:

$$\sum_{j=1}^{2} \sum_{i} X_{ij} \leq Q \text{ , } i = 1, \dots, n \tag{10}$$

Where Q is *bandwith* of 100MBps.

$$X_{ij} \geq L_{m_j} - (1 - Z_{ij}) \text{ , } i = 1, \dots, n; \ j = 1, 2, \dots \tag{11}$$

$$W_j \leq W_{ij} + (1 - Z_{ij}) \text{ , } i = 1, \dots, n; \ j = 1, 2, \dots \tag{12}$$

W_{ij} explains the user's *i* sensitivity price in class *j*.

$$X_{ij} \geq V_i - (1 - Z_{ij}) \text{ , } i = 1, \dots, n; \ j = 1, 2, \dots \tag{13}$$

Where V_i is minimum bandwidth for each user with $V_1 = 6$ Kbps for user 1 and $V_2 = 5$ Kbps for user 2.

$$X_{ij} \geq X_j - (1 - Z_{ij}) \text{ , } i = 1, \dots, n; \ j = 1, 2, \dots \tag{14}$$

$$X_{ij} \geq Z_{ij} \text{ , } i = 1, \dots, n; \ j = 1, 2, \dots \tag{15}$$

$$X_{ij} \geq 0 \text{ , } i = 1, \dots, n; \ j = 1, 2, \dots \tag{16}$$

$$L_{m_j} \geq 0.01 \text{ , } j = 1, 2, \dots \tag{17}$$

$$W_j \geq 0 \text{ , } j = 1, 2, \dots \tag{18}$$

$$X_{ij} \leq X_j, i = 1, \dots, n; \ j = 1, 2, \dots \tag{19}$$

$$Z_{ij} = \begin{cases} 1, & \text{if user } i \text{ is admitted to class } j \\ & 0, \text{otherwise} \end{cases} \tag{20}$$

4. Results and Discussion

For objective function (1) with subject to constraints (2)-(20), the optimal solution for 4 cases where the QoS attributes involving increment or decrement of price due to QoS change and increment or decrement of QoS value is solved using LINGO 11.0.

4.1. QoS Attribute: *Bandwith*

Table 1 and Table 2 depict the solver status for each 4 cases and decision variable value, respectively.

Tabel 1. Solver Status of Model Nonlinier Programming Model of Wireless Pricing Scheme for QoS Attribute: Bandwidth

Variables	PQ_{ij} increase x increase	PQ_{ij} increase x decrease	PQ_{ij} decrease x increase	PQ_{ij} decrease x decrease
Model Class	INLP	INLP	INLP	INLP
State	Local Optimal	Local Optimal	Local Optimal	Local Optimal
Objective	508632	508628	503863	503863
Infeasibility	0	0	0	$3.63798 \cdot 10^{-12}$
Iterations	31	32	28	28
GMU	35K	35K	35K	35K
ER	0s	0s	0s	0s

Table 1 displays the optimal solution for the bandwidth QoS attributes of the four cases. The value of the optimal solution can be viewed on objective row, which for QoS bandwidth available in four cases, the value will achieve the most optimal results in the first case which is 508632. These results will be obtained by performing iterations 31 times the infeasibility of 0. Generated Memory Used (GMU) shows the amount of used memory allocation that is equal to 35K and Elapsed Runtime (ER) shows the total time used to produce and finish the model that is 0 seconds.

Furthermore, Table 2 shows the decision variables for 2 users and 2 classes. Changes in costs due to changes in QoS for each case do not seem to approach the same value. Because for cases 1 and 2, the change fee will be close to 1, while in the case of 3 and 4, changes in the cost of even approaching 0.1. In addition, for cases 1 and 2, the increment or decrement in the value of QoS is 1 that shows the services are in perfect condition, as well as for cases 3 and 4, the increment or decrement in the value of QoS is 0 which indicates the service is in a state of best effort.

Tabel 2. Decision Variable Values of Model Nonlinier Programming Model of Wireless Pricing Scheme for QoS Attribute: Bandwidth

Variables	PQ_{ij} increase x increase	PQ_{ij} increase x decrease	PQ_{ij} decrease x increase	PQ_{ij} decrease x decrease
PQ_{11}	1.218333	1.217116	0.07381231	0.07381231
PQ_{12}	1.137111	1.135975	0.08857477	0.08857477
PQ_{21}	1.055889	1.054834	0.1033372	0.1033372
PQ_{22}	0.9746667	0.9736925	0.1180997	0.1180997
x	1	1	0	0
PB_{11}	0.5126671	0.5126671	0.04295705	0.04295705
PB_{12}	0.4784893	0.4784893	0.05154845	0.05154845
PB_{21}	0.4443115	0.4443115	0.06013986	0.06013986
PB_{22}	0.4101337	0.4101337	0.06873127	0.06873127
a_{11}	0.15	0.15	0.05	0.05
a_{12}	0.14	0.14	0.06	0.06
a_{21}	0.13	0.13	0.07	0.07
a_{22}	0.12	0.12	0.08	0.08
B	1.07	1.07	0.8	0.8

4.2. Atribut QoS *end-to-end delay*

Table 3 and Table 4 display the solver status and variable decision values for each case.

Tabel 3. Solver Status of Model Nonlinier Programming Model of Wireless Pricing Scheme for QoS Attribute: End-to-End Delay

Variables	PQ_{ij} increase x increase	PQ_{ij} increase x decrease	PQ_{ij} decrease x increase	PQ_{ij} decrease x decrease
Model Class	INLP	INLP	INLP	INLP
State	Local Optimal	Local Optimal	Local Optimal	Local Optimal
Objective	508643	508618	503863	503863
Infeasibility	$2.22045 \cdot 10^{-16}$	$1.09139 \cdot 10^{-11}$	0	0
Iterations	31	32	28	28
GMU	35K	35K	35K	35K
ER	0s	0s	0s	0s

Based on Table 3, it can be seen that the optimal solution occurs in the first case of 508643 with number of iteration of 31 iterations. For each case, the memory allocation looks the same value in the amount of 35K and ER of 0s. From Table 4 shows that in cases 1 and 2 the cost changes will be close to 1, while for cases 2 and 3 the cost changes in will be close to 0.1.

Tabel 4. Decision Variable Values of Model Nonlinier Programming Model of Wireless Pricing Scheme for QoS Attribute: End-to-End Delay

Variables	PQ_{ij} increase x increase	PQ_{ij} increase x decrease	PQ_{ij} decrease x increase	PQ_{ij} decrease x decrease
PQ_{11}	1.221204	1.214245	0.07381231	0.07381231
PQ_{12}	1.139790	1.133296	0.08857477	0.08857477
PQ_{21}	1.058377	1.052346	0.1033372	0.1033372
PQ_{22}	0.9769630	0.9713962	0.1180997	0.1180997
x	1	1	0	0
PB_{11}	0.5126671	0.5126671	0.04295705	0.04295705
PB_{12}	0.4784893	0.4784893	0.05154845	0.05154845
PB_{21}	0.4443115	0.4443115	0.06013986	0.06013986
PB_{22}	0.4101337	0.4101337	0.06873127	0.06873127
a_{11}	0.15	0.15	0.05	0.05
a_{12}	0.14	0.14	0.06	0.06
a_{21}	0.13	0.13	0.07	0.07
a_{22}	0.12	0.12	0.08	0.08
B	1.07	1.07	0.8	0.8

4.3. Atribut QoS *BER*

The solver status and variable decision values for each case are presented in Table 5 and Table 6 for Bit Rate Error (BER) QoS Attribute.

Tabel 5. Solver Status of Model Nonlinier Programming Model of Wireless Pricing Scheme for QoS Attribute: BER

Variables	PQ_{ij} increase x increase	PQ_{ij} increase x decrease	PQ_{ij} decrease x increase	PQ_{ij} decrease x decrease
Model Class	INLP	INLP	INLP	INLP
State	Local Optimal	Local Optimal	Local Optimal	Local Optimal
Objective	$4.38386 \cdot 10^7$	506541	503863	504246
Infeasibility	$7.27596 \cdot 10^{-12}$	0	$8 \cdot 10^{-8}$	0
Iterations	26	35	40	28
GMU	35K	35K	35K	35K
ER	0s	0s	1s	0s

For BER QoS Attribute, optimal results lies in the first case like stated in Table 5. However, it appears that the results obtained to be much larger than the existing three cases which is equal to $4.38386 \cdot 10^7$ with 26 iterations.

Changes in costs due to changes in QoS for each case seem to be approaching a different value altogether as Table 6 explained. For the case of 1, the cost changes will be close to 1, in the case of two changes in the cost will be close to 0.5, in the case of three changes in the cost will be close to 0:07, while in case 4 cost changes is at 0.

If we examine from Table 1, Table 3 and Table 5, we can compare the 3 QoS attribute according to each case. In the first case it appears that the optimal solution lies in QoS BER is equal to 4.38386×10^7, with the fewest iterations of 26 iterations. In the second case, the optimal solution instead lies in the QoS bandwidth that is equal to 508628, with 32 iterations where the number of iterations. In the third case the optimal solution from the same third QoS that is 503863, but the least iteration shown in bandwidth and end-to-end delay of 28 iterations. For the fourth case the optimal solution is the for bandwidth and end-to-end delay in the amount of 503863, where the optimal solution of both QoS can be obtained by 28 iterations.4.38386×10^7.

Also, if we analyze from previous research done by [13], our results show more on various values of factor of acceptance and cost factors affected the models. By incrementing or decrementing x as the QoS value, we obtain the best optimal value of charging the wireless network. Again, by examining the research conducting by [22] for pricing the services in differentiated network where the auction method used to solve the optimization problem, the problem actually only involves bandwidth as the QoS attributes, so the performance of other attributes are not clearly shown. With our results, other QoS attributes are also shown and in fact, BER shown better results than other attributes.

Tabel 6. Decision Variable Values of Model Nonlinier Programming Model of Wireless Pricing Scheme for QoS Attribute: BER

Variables	PQ_{ij} increase x increase	PQ_{ij} increase x decrease	PQ_{ij} decrease x increase	PQ_{ij} decrease x decrease
PQ_{11}	$1.217725 \cdot 10^7$	0.6372512	0.07381230	0
PQ_{12}	$1.136543 \cdot 10^7$	0.5947678	0.08857477	0
PQ_{21}	$1.055361 \cdot 10^7$	0.5522844	0.1033372	0
PQ_{22}	$0.9741797 \cdot 10^7$	0.5098010	0.1180997	0
x	1	0	0	$0.1 \cdot 10^{-6}$
PB_{11}	0.5126671	0.3708654	0.04295704	0.04295705
PB_{12}	0.4784893	0.3461410	0.05154845	0.05154846
PB_{21}	0.4443115	0.3214166	0.06013986	0.06013987
PB_{22}	0.4101337	0.2966923	0.06873127	0.06873128
a_{11}	0.15	0.15	0.05	0.05
a_{12}	0.14	0.14	0.06	0.06
a_{21}	0.13	0.13	0.07	0.07
a_{22}	0.12	0.12	0.08	0.08
B	1.07	0.8	0.8	0.8

5. Conclusion

There are three attributes of QoS in this discussion, namely bandwidth, end-to-end delay, and BER where each attribute has 4 cases. The optimal solution of the three QoS indicates that the results will be optimal if it is the first case where in case of increment of $\boldsymbol{PQ_{ij}}$ and increment of $\boldsymbol{x}$ when we have Bit Error Rate attribute.

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