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Bit Error Rate (BER) QoS Attribute in Solving Wireless Pricing Scheme on Single Link Multi Service Network

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ABSTRACT

Pricing schemes were set up on multi service network of wireless internet pricing scheme to proposed models applying Bit Error Rate QoS attribute due to requirements for ISP to maximize revenue and provide high quality of service to end users.The model was deigned by improving the original model together with added parameters and variables to the model of multi- service network by setting the base price (α) and premium quality (β) as variables and parameters. LINGO 11.0 were applied to help finding the solution. The results show that the improved models yield maximum revenue for ISP by applying the improved model by setting up a variable α and β as constant as well as by increasing the cost of all the changes in QoS. The QoS attriute BER is proven to achieve the ISP's goal to maximize the revenue.

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1. INTRODUCTION

The use of the internet by large segments of the community provides an important role in economic life. In this era of internet usage has reached the wireless internet. Economically, the use of wireless internet is cheaper than using a wired internet. This situation provides a great challenge for ISPs in arranging appropriate financing scheme and can provide maximum benefit ISPs and service users [1]. Many applications are developed by utilizing the wireless network, one of these are wireless sensor network applied in many application in wide area or technology [2] such as military or in agriculture [3], [4].

Problem of internet pricing was introduced by [5] and followed by [6-8] in wired network both multi classes and multi service. Then the research continue on focusing the wireless network with the advancement of this era. Problem concerning with the wireless network is not only focus on the pricing schemes but many aspect can be reviewed and discussed. Scheduling and routing are one of the probles occurring in optimizing the wireless network [9] or using heuristics method described in [10].

Recent research is already discussed by [11] that focused on pricing scheme on wireless of multi class QoS network where by applying some classes in single link network with the various QoS change and connection change. Their result can prove that by increasing connection cost and QoS change along with the cost change, can benefit providers by applying bit error rate (BER) QoS attribute. Based on the critical views of advancement of pricing strategy involving wireless network in multi service network, then it is important to have deeply discussion about that matter.

So, in this paper, the financing schemes bottled single link formed by with bit error rate QoS attribute and the network model multi service proposed by [12], [13] to fix the basic price (α) and premium (β) will be resolved by considering the financing model wireless networks optimally solved using LINGO program 11.0. the solution then will be compared to other QoS attribute to seek the best QoS attribute to be applied by ISP. The solutions can be expected to be used in order to maximize revenues ISP and provide the best quality services for users.

2. RESEARCH METHOD

In this study, the financing scheme single link wireless internet by multi service network is completed with 11.0 LINGO program that can solve the nonlinear model to get the optimal solution. The model used is modified model by combining the original model proposed by [14] with BER QoS attributes and in multi-service network model. The data used to test the model of secondary data obtained from one of the local server in Palembang, where data used consisted of mail, file and IP camera traffic data.

3. RESULTS AND ANALYSIS

This section explains about the model develop byapplying BER QoS attribute, along with the parameters and variables defined.

3.1. Modified Models

In the modified model, the model developed by combining with the network model in multi service network by adding parameters, variable decisions and constraints of each model and setting base price (α) and premium quality (β). wireless internet financing schemes on the modified model for QoS attribute BER is divided into four (4) cases based on the value of the model modification, $\boldsymbol{PQ_{ij}}$dan $\boldsymbol{x}$.

Parameters used in the modified models are as follows.

R : Function of revenue
PR_{ik} : Cost to connect with available QoS
PQ_{ik} : Cost changes along with QoS change
x : An increase or decrease on QoS value
Q_{bik} : Nominal value of QoS attributes in operator network
PB_{ik} : Base value for a connection in service *i* and link *k*
Lx : Linearity factor
a_{ik} : Linear cost factor in service *i* and link *k*
T_l : Traffic load
a : Predetermined linear parameter
B : Predetermined linear parameter
f : Minimum value set by service provider for a_{ik}
g : Maximum value set by service provider for a_{ik}
h : Number of minimum traffic load allowable for T_l
k : Number of maximum traffic load allowable for T_l
I_i : Quality index for service *i*
p_{ik} : Price for user of service *i* in link *k*
x_{ik} : Number of users in service *i* in link *k*
d_{ik} : Capacity needed for service *i* in link *k*
C_k : Total capacity in link *k*
a_{ik} : Total capacity of *i* in link *k*
m_i : QoS minimum for service *i*
n_i : Number of users in service *i*
l_i : Minimum quality premium for service *i*
b_i : Maximum kualitas premium untuk layanan *i*
y : Minimum base price for service *i*
z : Maximum base price for service *i*

There are four cases which are the case of α and β as parameters, as the case α and β parameter and variables, case α and β as variables and case variables α and β as parameter.

3.1.1. Modified Model for $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$ Parameter of BER QoS Attribute

Wireless pricing scheme model of modified case of α and β sebagai parameter, then the objective function will be as :

$$Max\ R = \sum_{k=1}^{r}\sum_{i=1}^{s} PR_{ik} \pm PQ_{ik} + \left((\alpha + \beta.I_i).p_{ik}.x_{ik}\right) \quad (1)$$

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Subject to

$$PQ_{11} = \left(1 \pm \frac{x}{10^{-7}}\right) PB_{11} Lx \quad (2)$$

$$PQ_{21} = \left(1 \pm \frac{x}{10^{-7}}\right) PB_{21} Lx \quad (3)$$

$$PQ_{31} = \left(1 \pm \frac{x}{10^{-7}}\right) PB_{31} Lx \quad (4)$$

$$PB_{11} = a_{11}(e - e^{-xB})T_l/100 \quad (5)$$

$$PB_{21} = a_{21}(e - e^{-xB})T_l/100 \quad (6)$$

$$PB_{31} = a_{31}(e - e^{-xB})T_l/100 \quad (7)$$

$$L_x = (e - e^{-xB}) \quad (8)$$

$$0.05 \le a_{11} \le 0.15 \quad (9)$$

$$0.06 \le a_{21} \le 0.14 \quad (10)$$

$$0.07 \le a_{31} \le 0.13 \quad (11)$$

$$50 \le T_l \le 1000 \quad (12)$$

$$0 \le x \le 1 \quad (13)$$

$$0.8 \le B \le 1.07 \quad (14)$$

$$a = 1 \quad (15)$$

$$I_1 x_{11} \le a_{11} \quad (16)$$

$$I_2 x_{21} \le a_{21} \quad (17)$$

$$I_3 x_{31} \le a_{31} \quad (18)$$

$$I_1 x_{11} + I_2 x_{21} + I_3 x_{31} \le C \quad (19)$$

$$a_{11} + a_{21} + a_{31} = 1 \quad (20)$$

$$0 \le a_{11} \le 1 \quad (21)$$

$$0 \le a_{21} \le 1 \quad (22)$$

$$0 \le a_{31} \le 1 \quad (23)$$

$$0.01 \le I_1 \le 1 \quad (24)$$

$$0.01 \le I_2 \le 1 \quad (25)$$

$$0.01 \le I_3 \le 1 \quad (26)$$

$$0 \le x_{11} \le 1 \quad (27)$$

$$0 \le x_{21} \le 10 \quad (28)$$

$$0 \leq x_{31} \leq 10 \tag{29}$$

$$\{x_{11}, x_{21}, x_{31}\} \subseteq \mathbb{Z}^+ \tag{30}$$

By modifying the index quality i (I_i) which is

if $I_i = I_{i-1}$, then add the constraint (31)

$$I_3 - I_2 = 0 \tag{32}$$

Based on Objectivefunction (1) and Equation (2) to Equation (32), the optimal solution for each case based on BER QoS attribute will be solvd by using LINGO 11.0.

Table 1. Optimal Solution of Modified Model of Wireless Internet Pricing Scheme on BER QoS Attribute for α and β Parameter

Variables	PQ_{ik} increase x increase	PQ_{ik} increase x decrease	PQ_{ik} decrease x increase	PQ_{ik} decrease x decrease
Model Class	INLP	INLP	INLP	INLP
State	Local Optimal	Local Optimal	Local Optimal	Local Optimal
Objective	5.64192×10^8	98.7587	67.7576	69.2338
Infeasibility	0	0	0	5.82×10^{11}
Iterations	14	21	12	13
GMU	32K	32K	32K	32K
ER	0s	0s	0s	0s

Based on Table 1, the value will achieve the most optimal results in the first case which is equal to 5.64192 x 108. These results will be obtained by iterating 14 iterations of the infeasibility of 0. Generated Memory Used (GMU) t is 32K and Elapsed Runtime (ER) is 0 seconds.

Based on Table 2 it can be seen that the values of variables PQ_{ij} for case 1 is very big, for case 2 and 3 is quite big, while in four case 4 the values of variables is 0. In case 1 the value of x is 1, whereas in cases 2 and 3 the value of x adala h 0, in case 4the value of x is 10-7 or close to 0. Value of PB_{ij} for case 1 and 2 is different but not much different whereas the value of PB_{ij} for cases 3 and 4 approaches 0 and quite different from the value of PB_{ij} in case 1 and 2. Values of L_x in case 1 is 2.375273 while in cases 1, 2 and 3, the cases have variable the same values of L_x. Value of aik in case 1 and 3 is the same one, not much different from the case 2 and case 4 in which case 2 and 4 have the values of the same variable.

Table 2. Value of Decision Variables in Modified Model for BER QoS Attribute for α and β Parameter

Variables	PQ_{ik} increase x increase	PQ_{ik} increase x decrease	PQ_{ik} decrease x increase	PQ_{ik} decrease x decrease
PQ_{11}	2.905738	2.902833	0.075407	0.075407
PQ_{21}	0.600000	7.894743	0.206674	0.206674
PQ_{31}	45.63906	49.59345	1.194164	1.194164
x	1	1	0	0
PB_{11}	1.222716	1.222716	0.043885	0.043885
PB_{21}	3.325383	3.325383	0.120279	0.120279
PB_{31}	19.20463	19.20463	0.694975	0.694975
PR_{11}	0.5	0.5	0.5	0.5
PR_{21}	0.6	0.6	0.6	0.6
PR_{31}	0.7	0.7	0.7	0.7
a_{11}	0.05	0.05	0.05	0.05
a_{21}	0.14	0.14	0.14	014
a_{31}	0.81	0,81	0.81	0.81
L_x	2.375273	2.375273	1.718282	1.718282
T_l	1000	1000	1000	1000
a	1	1	1	1
B	1.07	1.07	1.07	1.07
I_1	0.014	0.014	0.014	0.014
I_2	0.014	0.014	0.014	0.014
I_3	0.014	0.014	0.014	0.014
x_{11}	10	10	10	10
x_{21}	10	10	10	10
x_{31}	10	10	10	10

3.1.2. Modified Model of α Parameter and β Variable of BER QoS Attribute

The model of wireless pricing for the case of α parameter and β variable is as follows:

$$Max\ R = \sum_{k=1}^{r} \sum_{i=1}^{s} PR_{ik} \pm PQ_{ik} + ((\alpha + \beta_i . I_i). p_{ik} . x_{ik}) \quad (33)$$

Subject to Equation (2) to Equation (32) with added constraints as follows:

$$\beta_2 I_2 \geq \beta_1 I_1 \quad (34)$$

$$\beta_3 I_3 \geq \beta_2 I_2 \quad (35)$$

$$0{,}01 \leq \beta_1 \leq 0{,}5 \quad (36)$$

$$0{,}01 \leq \beta_2 \leq 0{,}5 \quad (37)$$

$$0{,}01 \leq \beta_3 \leq 0{,}5 \quad (38)$$

When we modify the quality index *i* (I_i) and quality premium (β_i) then

if $\beta_i = \beta_{i-1}$, add the cosntraints

$$\beta_2 - \beta_1 = 0 \quad (39)$$

$$\beta_3 - \beta_2 = 0 \quad (40)$$

According to objective (33) and Equation (2) to Equation (32) also Equation (34) to Equation (40) the optimal solution can be completed by applying LINGO 11.0.

Based on Table 3, the value achieves the most optimal results in the first case which is equal to 5.64192 x 108. These results will be obtained by iterating 13 times with the infeasibility of 0. The GMU is equal to 34k and ER is 0 seconds.

Table 3. Optimal Solution of Modified Model of Wireless Internet Pricing Scheme on BER QoS Attribute for α Parameter and β Variable

Variables	PQ_{ik} increase x increase	PQ_{ik} increase x decrease	PQ_{ik} decrease x increase	PQ_{ik} decrease x decrease
Model Class	INLP	INLP	INLP	INLP
State	Local Optimal	Local Optimal	Local Optimal	Local Optimal
Objective	5.64192×10^{8}	98.7487	67.7576	58.5797
Infeasibility	0	0	0	0
Iterations	13	15	11	13
GMU	34K	34K	34K	34K
ER	0s	0s	0s	0s

According to Table 4, it can be examined that the value of PQ_{ij} for case 1 is very big, while in case 2 and 3 are quite big and case 4 is 0. x value of case 1 *is* 1, as for case 2 and 3 are 0, then for case 4 is 10^{-7} or close to 0. PB_{ij} value for case 1 and 2 is not much different, but it occurs differently from case 1 and 2 for case 3 and 4 which are tend to 0 Value of L_x in case 1 is 2.375273 where I case 1, 2 and 3, the value of L_x is the same. Value of a_{ik} in case 1 and 3 is same, but not quite much different with the value of case 2 and 4 which have the same variable value.

Table 4 Value of Decision Variables in Modified Model for BER QoS Attribute for $\boldsymbol{\alpha}$ Parameter and $\boldsymbol{\beta}$ Variable

Variables	PQ_{ik} increase x increase	PQ_{ik} increase x decrease	PQ_{ik} decrease x increase	PQ_{ik} decrease x decrease
PQ_{11}	2.82 x 10^7	4.428739	0.073812	0
PQ_{21}	7.89 x 10^7	4.133489	0.206674	0
PQ_{31}	45.69 x 10^7	20.96270	1.195759	0
x	1	0	0	1 x 10^{-7}
PB_{11}	1.187637	2.577423	0.042957	0.128871
PB_{21}	3.325383	2.405595	0.120279	0.120279
PB_{31}	19.23971	12.19980	0.695904	0.609990
PR_{11}	0.5	0.5	0.5	0,5
PR_{21}	0.6	0.6	0.6	0,6
PR_{31}	0.7	0.7	0.7	0,7
a_{11}	0.05	0.15	0.05	0,15
a_{21}	0.14	0.14	0.14	0,14
a_{31}	0.81	0.71	0.81	0,71
L_x	2.375273	1.718282	1.718282	1.718282
T_l	1000	1000	1000	1000
a	1	1	1	1
B	1.07	1.07	1.07	1.07
I_1	0014	0.014	0.014	0.014
I_2	0.014	0.014	0.014	0.014
I_3	0.014	0.014	0.014	0.014
x_{11}	10	10	10	10
x_{21}	10	10	10	10
x_{31}	10	10	10	10
β_1	0.5	0.5	0.5	0.5
β_2	0.5	0.5	0.5	0.5
β_3	0.5	0.5	0.5	0.5

3.1.3. Modified Model for α dan β Variable of BER QoS attribute

The objective function will be

$$Max\ R = \sum_{k=1}^{r}\sum_{i=1}^{s} PR_{ik} \pm PQ_{ik} + ((\alpha_i + \beta_i.I_i).p_{ik}.x_{ik}) \quad (41)$$

Subject to Equation (2) to Equation (32) and Equation (36) to Equation (38) with added constraints as follows:

$$\alpha_2 + \beta_2 I_2 \geq \alpha_1 + \beta_1 I_1 \quad (42)$$

$$\alpha_3 + \beta_3 I_3 \geq \alpha_2 + \beta_2 I_2 \quad (43)$$

$$0 \leq \alpha_1 \leq 1 \quad (44)$$

$$0 \leq \alpha_2 \leq 1 \quad (45)$$

$$0 \leq \alpha_3 \leq 1 \quad (46)$$

and, if $\alpha_i = \alpha_{i-1}$, then

$$\alpha_2 - \alpha_1 = 0 \quad (47)$$

$$\alpha_3 - \alpha_2 = 0 \quad (48)$$

Next, for objective function (41) subject to Equation (2) to Equation (32), Equation (36) to Equation (38) and Equation (42) to Equation (48), the optimal solution for each case is completed with LINGO 11.0.

Based on Table 5 the value will achieve the most optimal results in the first case is equal to 5.64192 x 108. These results will be obtained by iterating by 14 iterations of the infeasibility of 0. The GMU is equal to 35K and ER is 0 seconds. According to Table 6 we can examine that the variable values of PQ_{ij} for case 1 is very big, for case 2 and 3 variable values PQ_{ij} are quite big, for case 4, the variable values for case 4

PQ_{ij} is 0. In case 1, the value x is 1, while for case 2 and 3 the value of x is 0, and for case 4 the value of x is 10^{-7} or close 0. The other values of decision variable can be seen completely in Table 5.

Table 5 Optimal Solution of Modified Model of Wireless Internet Pricing Scheme on BER QoS Attribute for α and β Variable

Variables	PQ_{ik} increase x increase	PQ_{ik} increase x decrease	PQ_{ik} decrease x increase	PQ_{ik} decrease x decrease
Model Class	INLP	INLP	INLP	INLP
State	Local Optimal	Local Optimal	Local Optimal	Local Optimal
Objective	5.64192 x 10^8	665,759	634,758	636,234
Infeasibility	0	0	4.43 x 10^{-2}	0
Iterations	14	14	32	23
GMU	35K	35K	35K	35K
ER	0s	0s	0s	0s

Table 6. Value of Decision Variables in Modified Model for BER QoS Attribute for $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$ Variable

Variables	PQ_{ik} increase x increase	PQ_{ik} increase x decrease	PQ_{ik} decrease x increase	PQ_{ik} decrease x decrease
PQ_{11}	2.82 x 10^7	4.428739	0.073812	0
PQ_{21}	7.89 x 10^7	4.133489	0.206674	0
PQ_{31}	45.69 x 10^7	20.96270	1.195759	0
x	1	0	0	1 x 10^{-7}
PB_{11}	1.187637	2.577423	0.042957	0.128871
PB_{21}	3.325383	2.405595	0.120279	0.120279
PB_{31}	19.23971	12.19980	0.695904	0.609990
PR_{11}	0.5	0.5	0.5	0.5
PR_{21}	0.6	0.6	0.6	0.6
PR_{31}	0.7	0.7	0.7	0.7
a_{11}	0.05	0.15	0,05	0.15
a_{21}	0.14	0.14	0.14	0.14
a_{31}	0.81	0.71	0.81	0.71
L_x	2.375273	1.718282	1.718282	1.718282
T_l	1000	1000	1000	1000
a	1	1	1	1
B	1.07	1.07	1.07	1.07
I_1	0.014	0.014	0.014	0.014
I_2	0.014	0.014	0.014	0.014
I_3	0.014	0.014	0.014	0.014
x_{11}	10	10	10	10
x_{21}	10	10	10	10
x_{31}	10	10	10	10
α_1	1	1	1	1
α_2	1	1	1	1
α_3	1	1	1	1
β_1	0.5	0.5	0.5	0.5
β_2	0.5	0.5	0.5	0.5
β_3	0.5	0.5	0.5	0.5

3.1.4. Modified Model Modifikasi for $\boldsymbol{\alpha}$ Variable and dan $\boldsymbol{\beta}$ Parameter of BER QoS Attribute

The objective function will be as follows.

$$Max\ R = \sum_{k=1}^{r}\sum_{i=1}^{s} PR_{ik} \pm PQ_{ik} + ((\alpha_i + \beta.I_i).p_{ik}.x_{ik}) \quad (49)$$

Subject to Equation (2) to Equation (32), Equation (47) to Equation (48) and Equation (44) to Equation (46) also, with added constraitns as follows:

$$\alpha_2 + I_2 \geq \alpha_1 + I_1 \quad (50)$$

$$\alpha_3 + I_3 \geq \alpha_2 + I_2 \quad (51)$$

Then the solution is presented in Table 7 and Table 8. In Table 7, the optimal solution is achieved in case 1 of 5.64192 x 10^8 while in Table 8 the solver status explains the detail of the solution done by LINGO 11.0.

Table 7. Optimal Solution of Modified Model of Wireless Internet Pricing Scheme on BER QoS Attribute for α Variable and β Parameter

Variables	PQ_{ik} increase x increase	PQ_{ik} increase x decrease	PQ_{ik} decrease x increase	PQ_{ik} decrease x decrease
Model Class	INLP	INLP	INLP	INLP
State	Local Optimal	Local Optimal	Local Optimal	Local Optimal
Objective	5.64192×10^{8}	665,759	634,758	636,234
Infeasibility	0	8.88×10^{-16}	2.28×10^{-2}	0
Iterations	15	20	29	21
GMU	35K	35K	35K	35K
ER	0s	0s	0s	0s

Table 8. Value of Decision Variables in Modified Model for BER QoS Attribute for α Variable and β Parameter

Variables	PQ_{ik} increase x increase	PQ_{ik} increase x decrease	PQ_{ik} decrease x increase	PQ_{ik} decrease x decrease
PQ_{11}	2.82×10^{7}	2.739399	0.073812	0
PQ_{21}	7.89×10^{7}	4.133489	0.206674	0
PQ_{31}	45.69×10^{7}	22.65204	1.195759	0
x	1	0	0	1×10^{7}
PB_{11}	1.187637	1.594266	0.042957	0.128871
PB_{21}	3.325383	2.405595	0.120279	0.120279
PB_{31}	19.23971	13.18296	0.695904	0.609990
PR_{11}	0.5	0.5	0.5	0.5
PR_{21}	0.6	0.6	0.6	0.6
PR_{31}	0.7	0.7	0.7	0.7
a_{11}	0.05	0.10	0.10	0.10
a_{21}	0,14	0.14	0.14	0.14
a_{31}	0.81	0.76	0.81	0,.1
L_x	2.375273	1.718282	1.718282	1.718282
T_l	1000	1000	1000	1000
a	1	1	1	1
B	1.07	1.07	1.07	1.07
I_1	0.014	0.014	0.014	0.014
I_2	0.014	0.014	0.014	0.014
I_3	0.014	0.014	0.014	0.014
x_{11}	10	10	10	10
x_{21}	10	10	10	10
x_{31}	10	10	10	10
α_1	1	1	1	1
α_2	1	1	1	1
α_3	1	1	1	1

Table 9, Table 10 and Table 11 displays the comparison between other QoS attribute such as bandwidth, End to End delay and BER. According to Table 10, the optimal solution .was achieved for case 3 and 4.

Table 9 The Comparison of Modified Model for Bandwidth QoS Attribute

Variables	Modified Model			
	α and β Parameter	α Parameter and β variable	α and β variable	α variable and β Parameter
Model Class	INLP	INLP	INLP	INLP
State	Local Optimal	Local Optimal	Local Optimal	Local Optimal
Objective	125.681	125.681	634.758	692.681
Infeasibility	0	1.5×10^{-2}	1.11×10^{-16}	0
Iterations	13	24	23	13
GMU	32K	32K	35K	35K
ER	0s	0s	0s	0s

It can be seen in Table 11, the same value occurs for ech case of BER QoS attribute which is 5,64192 x 10^{8}. It can be concluded for each QoS attribute, the optimal solution occurs in case 1 where increasing cost along with QoS change (PQ_{ik}) and increase the value of (x) where the revenue of IDR 564,192,000 is obtained.

Table 10. The Comparison of Modified Model for End To End QoS Attribute

Variables	Modified Model			
	α and β Parameter	α Parameter and β variable	α and β variable	α variable and β Parameter
Model Class	INLP	INLP	INLP	INLP
State	Local Optimal	Local Optimal	Local Optimal	Local Optimal
Objective	125.814	125.814	692.814	692.814
Infeasibility	0	0	0	0
Iterations	13	12	12	12
GMU	32K	34K	35K	35K
ER	0s	0s	0s	0s

Table 11. The Comparison of Modified Model for BER Attribute

Variables	Model Modifikasi			
	α and β Parameter	α Parameter and β variable	α and β variable	α variable and β Parameter
Model Class	INLP	INLP	INLP	INLP
State	Local Optimal	Local Optimal	Local Optimal	Local Optimal
Objective	5.64192×10^8	5.64192×10^8	5.64192×10^8	5.64192×10^8
Infeasibility	0	0	0	0
Iterations	14	13	14	15
GMU	32K	34K	35K	35K
ER	0s	0s	0s	0s

4. CONCLUSION

According to results above, the model for each attribute, we can conclude that ISP obtains maximum revenue by fixing the pricing strategy in multi service according to BER QoS attribute by increasing the cost along QoS change (PQ_{ik}) and the value of QoS (x) eith the profit of IDR 564,192,000.

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