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Improved Incentive Pricing Model of Wireless Pricing Scheme with End-to-End Delay Attribute

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Abstract. The ISP always faces a constant challenge between providing a high quality of service to the customer and between the pricing of a service that makes a profit and also pricing that suits the condition of the network and prevents excessive use when congestion occurs. This challenge is in balancing the volume of the demand with the volume of the bandwidth of the resource, as the greater the demand for a service, the less bandwidth is available. The End-to-End Delay feature was implemented in the pricing schemes for multi-service wireless Internet, by adding parameters, where we focused on determining the basic price of the service (alpha) and the quality of service (beta) as variables and constants as well as factors in the improved model that take into account the balance between the services provided as a base load factor, and all solutions extracted into models based on Lingo 18. It became clear from the results that, modifying the alpha and beta variables in the improved model, whether the beta is fixed or variable, with alpha is variable not a constant will achieve the maximum income for the service Provider.

INTRODUCTION

The Internet has become used in many fields, especially with the great development in the world of communications [1]. This development was reflected in the increase in the amount of voice and video being sent over the network, which imposed a challenge on the Internet service provider in providing quality of service in light of congestion, especially in wireless networks [2]. ISPs are faced with providing high quality services in view of the high demand, this necessitates pricing plans that include quality of service [3,4]. Service quality has a positive relationship between it and customer satisfaction and profit [5].

The pricing concept came about in response to new demands placed on network performance, especially real-time multimedia applications that have acceptable delay constraints or time delays when routing information over the network [6]. The pricing schemes that were used in the past were not appropriate because they charged small fees only when congestion occurred and the quality of service was deteriorating and this did not take into account the increased demand on the Internet and the diversity of services [7]. Developed a pricing scheme based on reverse charging scheme in 3G and 4G wireless network [8].

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Also according to [9] worked to get the optimum profit by combined utility functions with pricing strategy to obtain information on marginal costs, profit control, and consumer satisfaction. They discussed adding three wireless network features are bandwidth, end-to-end delay, and BER to improve a wireless pricing scheme revenue for a multi-service network [10]. Improved Internet pricing scheme in multiple links with multiple quality service networks using incentive mechanism and adoption parameters dependent on the quality of service [11].

They have focusing for designing incentive a wireless pricing scheme that supports a single-link multiservice network with the bandwidth attribute by specifying base price (alpha) for QoS and premium (beta) as variables and parameters, the results proved that when the cost of all changes in service quality is increased and the variable α and is set as fixed or variable, the service provider makes the best profit [12]. They have improved the pricing of single link in the wireless network by focusing on bandwidth attribute, by setting up a variable base price and quality of service constant in addition increasing the cost of all changes in the QoS [13].

Integrated the incentive mechanism in multi-service networks to work to prevent network resources in peak times by consumers by motivational pricing [14]. Improved pricing on the basis of the quasi-linear utility function which the model consists of Bundling problem model, consumer problem and quasi-linear utility function on multiple QoS network [15]. Improving wireless internet pricing using reverse charging with the end-to-end delay QoS attribute [16]. Designed wireless internet pricing optimization schemes in a single-link, multi-service network that implement the Bit error Rate feature by specifying base price (α) and premium quality (β) as parameters and variable [17] used the incentive mechanism in the pricing of wireless multi-service networks with a single link [18]. Enhanced internet pricing in wireless networks single link with bandwidth QOS attribute [12].

We have observed little work on the catalytic mechanism in Internet pricing networks as well as the end-to-end lag feature. The use of incentive to control users' use of the Internet will have an economic impact on the user to rationalize Internet consumption at peak times. In this paper, we address the pricing of wireless networks with a single connection, the end-to-end delay feature, and we compare the results with the previous model that dealt with the bandwidth characteristic [12]. First, we explain the results of the model based on the end-to-end delay feature, and then we explain the difference in results in the last section to compare the two models.

IMPROVED MODELS

The base price (α), premium quality (β) for each service category will be determined by combining the incentive mechanism and the wireless multi-service network model. We improved models by 4 cases:

α and β constants.
α constants and β variable.
α and β variables.
α variables and β constants.
Parameters used in the modified models are as follows:
i : priority of the service.
C : total bandwidth capacity of link K.
C_{ik}: bandwidth capacity of class in link K. Lbase: base load factor for the network.
b_{ik}: requested bandwidth of class i in link k.
R_{ik}: price service class i at link k.
p_{ik}: load factor for service class i at link k.
L_{ik}: load of service class i at link k.
I_i : quality of service index i.
a_{ik}: Linear cost factor in service i and links k.
mi : minimum QoS for service i.
I : the minimum premium for the service i.
b_i: the maximum premium for the service i.
y: the minimum base price for service i.
z: the maximum base price for service i.

Improved model case α and β constants:

Wireless pricing schemes in the first case, the objective function is as follows:

$$MAX = \sum^{r}{}_{k} \sum (PR_{ik} \pm PQ_{ik}) + ((\alpha + B * I_i) + R_{ik} * Z_{ik} * P_{ik}) \quad (1)$$

Subject to:

$$PQ_{11} = \left(1 \pm \frac{x}{350}\right) PB_{11} LX \quad (2)$$

$$PQ_{21} = \left(1 \pm \frac{x}{350}\right) PB_{21} LX \quad (3)$$

$$PQ_{31} = \left(1 \pm \frac{x}{350}\right) PB_{31} LX \quad (4)$$

$$PB_{11} = \alpha_{11}(e - e^{-XB})_1/100 \quad (5)$$

$$PB_{21} = \alpha_{21}(e - e^{-XB})_1/100 \quad (6)$$

$$PB_{31} = \alpha_{31}(e - e^{-XB})\, T_1/100 \quad (7)$$

$$LX = (e - e^{-XB}) \quad (8)$$

$$0.05 \leq \alpha_{11} \leq 0.15 \quad (9)$$

$$0.06 \leq \alpha_{21} \leq 0.14 \quad (10)$$

$$0.07 \leq \alpha_{31} \leq 0.13 \quad (11)$$

$$50 \leq T_1 \leq 1000 \quad (12)$$

$$0 \leq X \leq 1 \quad (13)$$

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

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

$$P_{11} \left(\frac{1 - L_{base}}{1 - L_{11}}\right)^n \quad (16)$$

$$P_{21} \left(\frac{1 - L_{base}}{1 - L_{21}}\right)^n \quad (17)$$

$$P_{31} \left(\frac{1 - L_{base}}{1 - L_{31}}\right)^n \quad (18)$$

$$L_{base} \leq L_{11} \leq 1 \quad (19)$$

$$L_{base} \leq L_{21} \leq 1 \quad (20)$$

$$L_{base} \leq L_{31} \leq 1 \quad (21)$$

$$0 \leq L_{base} \leq 1 \quad (22)$$

$$1 \leq n \leq 2 \quad (23)$$

$$C_1 + C_2 + C_3 = C \quad (24)$$

$$b_1 \leq C_1 \quad (25)$$

$$b_2 \leq C_2 \quad (26)$$

$$b_3 \leq C_3 \quad (27)$$

$$I_1 P_{11} \leq a_{11} \quad (28)$$

$$I_2 P_{21} \leq a_{21} \quad (29)$$

$$I_3 P_{31} \leq a_{31} \quad (30)$$

$$I_1 P_{11} + I_2 P_{21} + I_3 P_{31} \leq C \quad (31)$$

$$a_{11} + a_{21} + a_{31} = 1 \quad (32)$$

$$0 \leq a_{11} \leq 1 \quad (33)$$

$$0 \leq a_{21} \leq 1 \quad (34)$$

$$0 \leq a_{31} \leq 1 \quad (35)$$

$$0.01 \leq I_1 \leq 1 \quad (36)$$

$$0.01 \leq I_2 \leq 1 \quad (37)$$

$$0.01 \leq I_3 \leq 1 \quad (38)$$

By modifying the index of quality of services (I_i):

$$I_i = I_{i-1} \quad (39)$$
$$I_2 - I_1 = 0 \quad (40)$$
$$I_3 - I_2 = 0 \quad (41)$$

Improved model case α constants and β variable:

Wireless pricing schemes in the second case, the objective function is as follows:

$$MAXR = \sum^{r}{}_{k} \sum^{s}{}_{i} (PR_{ik} \pm PQ_{ik}) + ((\alpha + B_i * I_i) + R_{ik} * Z_{ik} * P_{ik}) \quad (42)$$

With subject to equations (2)-(15), as well as the added constraints:

$$B_2 I_2 \geq B_1 I_1 \quad (43)$$
$$B_3 I_3 \geq B_2 I_2 \quad (44)$$
$$0.01 \leq B_1 \leq 0.5 \quad (45)$$
$$0.01 \leq B_2 \leq 0.5 \quad (46)$$
$$0.01 \leq B_3 \leq 0.5 \quad (47)$$

$\beta_i = \beta_{i-1}$ by modifying the service quality index i (I_i) and the premium quality of service then added constraints:

$$B_2 - B_1 = 0 \quad (48)$$
$$B_3 - B_2 = 0 \quad (49)$$

Improved model case α and β variables

Wireless pricing schemes in third case, the objective function is as follow:

$$MAXR = \sum^{r}{}_{k} \sum^{s}{}_{i} (PR_{ik} \pm PQ_{ik}) + ((\alpha_i + B_i * I_i) + R_{ik} * Z_{ik} * P_{ik}) \quad (50)$$

With subject to equations (2-15) and equations (28-35), as well as the added constraints

$$\alpha_2 + B_2 I_2 \geq \alpha_1 + B_1 I_1 \quad (51)$$
$$\alpha_3 + B_3 I_3 \geq \alpha_2 + B_2 I_2 \quad (52)$$
$$0 \leq \alpha_1 \leq 1 \quad (53)$$
$$0 \leq \alpha_2 \leq 1 \quad (54)$$
$$0 \leq \alpha_3 \leq 1 \quad (55)$$

$a_i = a_{i-1}$ by modifying the service quality index i(l_1) and set a base price and premium service and added constraints:

$$\alpha_2 - \alpha_1 = 0 \quad (56)$$
$$\alpha_3 - \alpha_2 = 0 \quad (57)$$

Improved model case α variables and β constants

Wireless pricing schemes in fourth case, the objective function is as follow:

$$MAXR = \sum^{r}{}_{k} \sum^{s}{}_{i} (PR_{ik} \pm PQ_{ik}) + ((\alpha_i + B * I_i) + R_{ik} * Z_{ik} * P_{ik}) \quad (58)$$

with subject to equations (2)-(12) ,(14-(24). (35)-(38), with added constraints as follows:

$$a_2 + I_2 \geq a_1 + I_1 \quad (59)$$
$$a_3 + I_3 \geq a_2 + I_2 \quad (60)$$

RESULTS AND DISCUSSIONS

In this section, the results of the four cases that were presented in the second section are presented. The solution for each case consists of two parts. The first is to display the optimal solution, and the second represents the value of the variables in the model.

α and β constants in end-to-end delay QoS

Based on the objective function (1) with constraints (2-41), the optimal solution in each case on end-to-end delay QoS attributes solved using LINGO 18.0 are presented in table-1and table-2. the value achieved the most optimal results in the first case is equal to 791.567. These results obtained by iterating by 8 iterations of the infeasibility of 0. Generated Memory Used (GMU) that is 40 k and Elapsed Runtime (E) is 0 seconds.

TABLE 1. Optimal Solution for Models For α and β Constants in End-To-End Delay Qos

Var	PQ_{ij} increase x increase	PQ_{ij} increase x decrease	PQ_{ij} decrease x increase	PQ_{ij} decrease x decrease
Model Class	NLP	NLP	NLP	NLP
State	Local opt	Local opt	Local opt	Local opt
Objective	791.567	791.245	733.511	733.511
Infeasibility	0	0	0	0
Iter	8	8	8	8
GMU	40	40	40	40
ER	0	0	0	0

TABLE 2. Optimal Solution for Models For α And β

Var	PQ_{ij} increase x increase	PQ_{ij} increase x decrease	PQ_{ij} decrease x increase	PQ_{ij} decrease x decrease
PQ_{11}	8.487065	8.438705	0.2214369	0.2214369
PQ_{21}	7.921260	7.876125	0.2066745	0.2066745
PQ_{31}	40.17211	39.94321	1.048135	1.048135
X	1	1	0	0
PB_{11}	3.562910	3.562910	0.042957	0.042957
PB_{21}	3.325383	3.325383	0.060139	0.060139
PB_{31}	16.86444	16.86444	0.068731	0.068731
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}	0.15	0.15	0.05	0.05
a_{21}	0.14	0.14	0.06	0.06
a_{31}	0.71	0.71	0.07	0.07
Lx	2.375273	2.375273	1.718282	1.71828
T_l	1000	1000	50	50

a	1	1	0	0
B	1.07	1.07	0.8	0.8
I_1	0.2983710	0.2983710	0.2983710	0.2983710
I_2	0.2983710	0.2983710	0.2983710	0.2983710
I_3	0.2983710	0.2983710	0.2983710	0.2983710
P_{11}	0.5072075	0.5072075	0.5072075	0.5072075
P_{21}	0.4717468	0.4717468	0.4717468	0.4717468
P_{31}	0.4258186	0.4258186	0.4258186	0.4258186
L_{11}	0,3	0.3	0.3	0.3
L_{21}	0.33	0.33	0.33	0.33
L_{31}	0.37	0.37	0.37	0.37
R_{11}	0.00007	0.00007	0.00007	0.00007
R_{21}	0.0006	0.0006	0.0006	0.0006
R_{31}	0.005	0.005	0.005	0.005

α Constant and β variable in end-to-end delay QoS

Based on the objective function (42) and constraints (2-15). The optimal solution is summarized in Tables 3 and 4 for each case of the end-to-end delay features. We notice from tables (3,4) the first case achieved optimal results compared to the rest of the cases, where the objective is 791.567, the results are reached after 8 iterations. ZERO invisibility, 41 K memory usage, and zero runtime. the results of the values in first and second cases are similar, while the third and fourth cases are identical.

TABLE 3. Optimal Solution for Models For α Constant And β Variable in End-To-End Delay Qos

Var	PQ_{ij} increase x increase	PQ_{ij} increase x decrease	PQ_{ij} decrease x increase	PQ_{ij} decrease x decrease
Model Class	NLP	NLP	NLP	NLP
State	Local Opt	Local Opt	Local Opt	Local Opt
Objective	791.567	791.245	733.511	733.511
Infeasibility	0	0	0	0
Iter	8	8	6	6
GMU	41	41	41	41
ER	0	0	0	0

TABLE 4. Variable Values for Models α Constant and β Variable

Var	PQ_{ij} increase x increase	PQ_{ij} increase x decrease	PQ_{ij} decrease x increase	PQ_{ij} decrease x decrease
PQ_{11}	8.487065	8.438705	0.2214369	0.2214369
PQ_{21}	7.921260	7.876125	0.2066745	0.2066745
PQ_{31}	40.17211	39.94321	1.048135	1.048135
X	1	1	0	0
PB_{11}	3.562910	3.562910	0.042957	0.042957
PB_{21}	3.325383	3.325383	0.060139	0.060139

PB_{31}	16.86444	16.86444	0.068731	0.068731
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}	0.15	0.15	0.05	0.05
a_{21}	0.14	0.14	0.06	0.06
a_{31}	0.71	0.71	0.07	0.07
Lx	2.375273	2.375273	1.718282	1.71828
T_1	1000	1000	50	50
a	1	1	0	0
B	1.07	1.07	0.8	0.8
I_1	0.2983710	0.2983710	0.2983710	0.2983710
I_2	0.2983710	0.2983710	0.2983710	0.2983710
I_3	0.2983710	0.2983710	0.2983710	0.2983710
P_{11}	0.5072075	0.5072075	0.5072075	0.5072075
P_{21}	0.4717468	0.4717468	0.4717468	0.4717468
P_{31}	0.4258186	0.4258186	0.4258186	0.4258186
L_{11}	0,3	0.3	0.3	0.3
L_{21}	0.33	0.33	0.33	0.33
L_{31}	0.37	0.37	0.37	0.37
R_{11}	0.00007	0.00007	0.00007	0.00007
R_{21}	0.0006	0.0006	0.0006	0.0006
R_{31}	0.005	0.005	0.005	0.005

α and β variable in end-to-end delay QoS:

Based on the objective function (50) and the equations from (2-15). and (28-35) and additional constraints (51-57). The optimal solution is summarized in Tables 5 and 6 for each case.

We note from table 5 that the first case achieved the best result (794.267), 8 iterations and the value of the memory used is 42 k. From table.6 we notice that the values of the variables in the first and second cases are close, while in the 3 and 4 the results are identical.

TABLE 5. Optimal Solutions for Models for α and β Variable in End-to-End Delay Qos

Var	PQ_{ij} Increase x increase	PQ_{ij} Increase x decrease	PQ_{ij} decrease x increase	PQ_{ij} decrease x decrease
Model Class	NLP	NLP	NLP	NLP
State	Local Opt	Local Opt	Local Opt	Local Opt
Objective	794.267	793.945	736.211	736.211
Infeasi bility	0	0	0	0
Iter	8	8	8	8
GMU	42	42	42	42
ER	0	0	0	0

TABLE 6. Variable Values for Models for α and β Variable

Var	PQij increase x increase	PQij increase x decrease	PQij decrease x increase	PQij decrease x decrease
PQ_{11}	8.487065	8.438705	0.2214369	0.2214369
PQ_{21}	7.921260	7.876125	0.2066745	0.2066745
PQ_{31}	40.17211	39.94321	1.048135	1.048135
X	1	1	0	0
PB_{11}	3.562910	3.562910	0.1288711	0.1288711
PB_{21}	3.325383	3.325383	0.1202797	0.1202797
PB_{31}	16.86444	16.86444	0.6099900	0.6099900
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}	0.15	0.15	0.15	0.15
a_{21}	0.14	0.14	0.14	0.14
a_{31}	0.71	0.71	0.71	0.71
Lx	2.375273	2.375273	1.718282	1.71828
T_1	1000	1000	50	50
a	1	1	0	0
B	1.07	1.07	0.8	0.8
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
I_1	0.2983710	0.2983710	0.2983710	0.2983710
I_2	0.2983710	0.2983710	0.2983710	0.2983710
I_3	0.2983710	0.2983710	0.2983710	0.2983710
α_1	1	1	1	1
α_2	1	1	1	1
α_3	1	1	1	1
L_{11}	0,3	0.3	0.3	0.3
L_{21}	0.33	0.33	0.33	0.33
L_{31}	0.37	0.37	0.37	0.37
R_{11}	0.00007	0.00007	0.00007	0.00007
R_{21}	0.0006	0.0006	0.0006	0.0006
R_{31}	0.005	0.005	0.005	0.005

α variable and β constants in end-to-end delay QoS

Based on the objective function (58) and the equations from (2-12)., (14-24), (35–38), additional constraints (59) and (60). The optimal solution is summarized in table 7 and 8. We note from Table No. 7 that the first case achieved the best result (794.267), it needed to get the results 8 iterations and the value of the memory used is 42 k. From Table No.8 we notice that the values of the variables in the first and second cases are close, while in the case 3 and 4 the results are identical.

TABLE 7. Optimal Solutions for Models α Variable and β Constants in End-To-End Delay Qos

Var	PQij increase x increase	PQij Increas x decrease	PQij decreas x increase	PQij decrease x decrease

Model Class	NLP	NLP	NLP	NLP
State	Loca l Opt	Loca l Opt	Local Opt	Local Opt
Objective	794.267	793.945	736.211	736.211
Infeasibility	0	0	0	0
Iter	8	8	8	8
GMU	42	42	42	42
ER	0	0	0	0

TABLE 8. Variable Values for Models for α Variable and β Constants

Var	PQ_{ij} increase $\boldsymbol{x}$ increase	PQ_{ij} Increase $\boldsymbol{x}$ decrease	PQ_{ij} decrease $\boldsymbol{x}$ increase	PQ_{ij} decrease $\boldsymbol{x}$ decrease
PQ_{11}	8.487065	8.438705	0.2214369	0.2214369
PQ_{21}	7.921260	7.876125	0.2066745	0.2066745
PQ_{31}	40.17211	39.94321	1.048135	1.048135
X	1	1	0	0
PB_{11}	3.562910	3.562910	0.1288711	0.1288711
PB_{21}	3.325383	3.325383	0.1202797	0.1202797
PB_{31}	16.86444	16.86444	0.6099900	0.6099900
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}	0.15	0.15	0.15	0.15
a_{21}	0.14	0.14	0.14	0.14
a_{31}	0.71	0.71	0.71	0.71
Lx	2.375273	2.375273	1.718282	1.71828
T_1	1000	1000	50	50
a	1	1	0	0
B	1.07	1.07	0.8	0.8
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
I_1	0.2983710	0.2983710	0.2983710	0.2983710
I_2	0.2983710	0.2983710	0.2983710	0.2983710
I_3	0.2983710	0.2983710	0.2983710	0.2983710
α_1	1	1	1	1
α_2	1	1	1	1
α_3	1	1	1	1
L_{11}	0,3	0.3	0.3	0.3
L_{21}	0.33	0.33	0.33	0.33
L_{31}	0.37	0.37	0.37	0.37
R_{11}	0.00007	0.00007	0.00007	0.00007
R_{21}	0.0006	0.0006	0.0006	0.0006
R_{31}	0.005	0.005	0.005	0.005

RESULTS COMPARISON

In this section, we compare the results between our model that uses the end-to-end delay feature and our model that we designed previously (9), which is based on the bandwidth feature. The comparison will be between the optimal solution in each case between the two models.

TABLE 9. Optimal Solutions for Models 4 Cases in End-To-End Delay Qos.

Var	α and β const	α const β var	α and β var	α var β const
Model Class	NLP	NLP	NLP	NLP
State	local Opt	Local Opt	Local Opt	Local Opt
Objet	791.567	791.567	794.267	794.267
Infeasibility	0	0	0	0
Iterations	8	8	8	8
GMU	41	41	41	42
ER	0s	0s	0s	0s

TABLE 10. Optimal Solutions for Models 4 Cases in Bandwidth Qos

Var	α and β const	α const β var	α and β var	α var β const
Model Class	NLP	NLP	NLP	NLP
State	Local Opt	Local Opt	Local Opt	Local Opt
Objet	791.567	791.434	794.120	794.134
Infeasibility	0	0	0	0
Iterations	14	14	14	14
GMU	44	44	44	44
ER	0s	0s	0s	0s

From Table 9, we note that the optimal solution is when α is variable and the β is either constant or variable with increasing cost of all changes in QoS, the optimal revenue is 794.267 with 8 iterations and 42 GMU. While in the previous model in table 10, which was based on the bandwidth feature, it achieved a profit of 794,134 with 44 iteration, and GMU 44 K.

CONCLUSION

Pricing and imposing a price on the Internet are closely related to the type of quality that the user receives from the service provider. The price varies according to the quality. Based on the comparison of the results between the two models, it became clear to us that by setting the base price (α) as a variable and the premium service price as a fixed or variable (β), in addition to increasing the value of changes in service quality, the ISP will obtain the maximum profit of five hundred thousand. For more future studies, it is possible to use other parameters of the quality of service in wireless networks and compare the results with this model to reach the best incentive pricing scheme in the field of Internet pricing in wireless networks.

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