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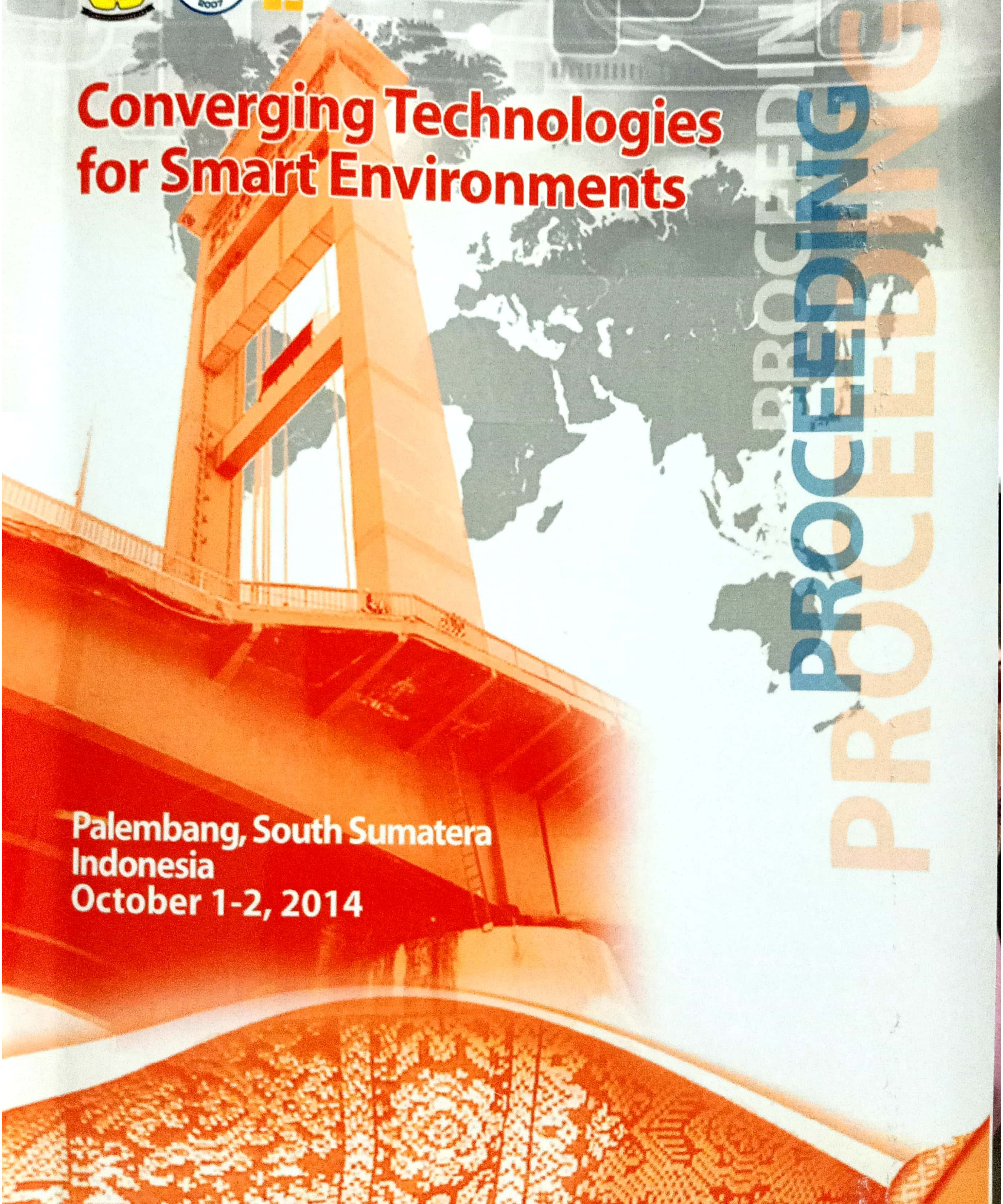

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Articles

An Improved Model of Internet Pricing Scheme Of Multi Link Multi Service Network With Various Value of Base Price, Quality Premium and QoS Level

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Abstract— **Internet Service Providers (ISPs) nowadays deal with high demand to promote good quality information. However, the knowledge to develop new pricing scheme that serve both customers and supplier is known, but only a few pricing plans involve QoS networks. This study will seek new proposed pricing plans offered under multi link multi service networks. The multi link multi service networks scheme is solved as an optimization model by comparing our four cases set up to achieve ISPs goals in obtaining profit. The decisions whether to set up base price to be fixed to recover the cost or to be varied to compete in the market are considered. Also, the options of quality premium to be fixed to enable user to choose classes according to their preferences and budget or to be varied to enable ISP to promote certain service are set up. Finally, we compare the previous research with our model to obtain better result in maximizing the ISPs profit.**

***Keywords*— multi link multi service network, internet pricing, base price, quality premium, QoS level**

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 auction pricing scheme is actually scalability, efficiency and fairness in sharing resources (see in [4-10]).

Recent studies have also been conducted to address problem of multiple service network, other kind of pricing scheme in network. Sain and Herpers [11] 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, [12, 13] discussed the new approach and new improved model of [11, 14] 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 [14-17], 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, 13, 14, 18] into new formulation 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 more than one link and also bandwidth required. The problem of internet charging scheme is considered as Mixed Integer Nonlinear Programming (MINLP) to obtain optimal solution by using LINGO 13.0 [19] 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 of multi link multi service networks Again, we formulate the problem as MINLP that can be solved by nonlinear programming method to obtain exact solution.

II. Past Literature Review

Table I and Table II below present the several past research focusing on internet pricing and current research on wired internet pricing under multiple QoS network.

TABLE I
SEVERAL PAST RESEARCH ON INTERNET PRICING

Pricing Strategy	How it Works
Responsive Pricing [20]	Three stages proposed consist of not using feedback and user adaptation, using the closed-loop feedback and one variation of closed loop form.
Pricing plan [21]	It Combines the flat rate and usage based pricing. Proposed pricing scheme offers the user a choice of flat rate basic service, which provides access to internet at higher QoS, and ISPs can reduce their peak load.
Pricing strategy [14]	Based on economic criteria. They Design proper pricing schemes with quality index yields simple but dynamic formulas'. Possible changes in service pricing and revenue changes can be made
Optimal pricing strategy [22]	The schemes are Flat fee, Pure usage based, Two part tariff. Supplier obtains better profit if chooses one pricing scheme and how much it can charge. Two part of analysis homogenous and heterogeneous.
Paris Metro Pricing [23, 24]	Different service class will have a different price. The scheme makes use of user partition into classes and move to other class it found same service from other class with lower unit price.

TABLE II
CURRENT RESEARCH CONDUCTED ON WIRED INTERNET NETWORKS

Method	How It works
New Approach on solving optimization of internet pricing scheme in multiservice networks proposed by Puspita et al [12]	By comparing with previous work done by Sain and Herpers [11], we obtain better result done by LINGO 13.0. Work in multi service network with availability of QoS level.
Improved Model of internet pricing scheme in single bottleneck multi service network proposed by Puspita et al.[6] and in multiple bottleneck links proposed by Puspita et al. [18]	By improving and modifying the method proposed by Sain and Herpers [11] and Byun and Chatterjee [14], the new improved methods are proven to result in better profit for ISP. The improved model proposed works in single and multiple bottleneck links in multiservice network which has QoS level for each service.
Improved Model of internet pricing scheme in single bottleneck and multi bottleneck links in multiple QoS networks proposed by Puspita et al. [4], Puspita et al. [5-9]	By Improving and modifying the method proposed by Yang [1], Yang et al. [2, 3, 25] and Byun and Chatterjee [14], the new improved models that are solved by LINGO 13.0 can perform better results that maximize the ISP profit. The models work on both single and multiple bottleneck links in multi QoS networks.

III. MODEL FORMULATION

We have parameters as follows (adopted in [18]).

α_j : base price for class j, can be fixed or variables

β_j : quality premium of class j that has I_j service performance

C_l : total capacity available in link l

p_{il} : price a user willing to pay for full QoS level service of i in link l

The decision variables are as follows.

x_{il} : number of users of service i in link l

a_{il} : reserved share of total capacity available for service i in link l

I_i : quality index of class i

Formulation when we assign α and β fixed is as follows.

$$\max \sum_{l=1}^{L} \sum_{i=1}^{S} (\alpha + \beta I_i) p_{il} x_{il} \quad (1)$$

Such that

$$I_i\, d_{il}\, x_{il} \le a_{il}\, C_l,\ i = 1, \dots S,\ l=1, \dots, L \quad (2)$$

$$\sum_{l=1}^{L} \sum_{i=1}^{S} I_i\, d_{il} x_{il} \le C_l, i = 1, \cdots, S; l = 1, \cdots, L \quad (3)$$

$$\sum_{l=1}^{L} a_{il} = 1, i = 1, \cdots, S \quad (4)$$

$$0 \le a_{il} \le 1, i = 1, \cdots, S; l = 1, \cdots, L \quad (5)$$

$$m_i \le I_i \le 1, i = 1, \cdots, S \quad (6)$$

$$0 \le x_{il} \le n_i, i = 1, \cdots, S;\ l = 1, \cdots, L \quad (7)$$

With m_i and n_i are prescribed positive integer numbers.

$$\{x_{il}\}\text{integer} \quad (8)$$

Formulation when we assign α fixed and β vary is as follows.

$$max \sum_{l=1}^{L} \sum_{i=1}^{S} (\alpha + \beta_i I_i) p_{il} x_{il} \quad (9)$$

subject to (2)-(8) with additional constraints as follows.

$$\beta_i I_i \ge \beta_{i-1} I_{i-1}, i > 1, i = 1, \cdots, S \quad (10)$$

$$k \le \beta_i \le q, [k, q] \in [0,1] \quad (11)$$

Formulation we have when α and β vary

$$max \sum_{l=1}^{L} \sum_{i=1}^{S} (\alpha_i + \beta_i I_i) p_{il} x_{il} \quad (12)$$

Subject to Constraint (2)-(8) and (10) with additional constraints

$$\alpha_i + \beta_i I_i \ge \alpha_{i-1} + \beta_{i-1} I_{i-1}, i > 1, i = 1, \cdots, S \quad (13)$$

$$y \le \alpha_i \le z, [y, z] \in [0,1] \quad (14)$$

Formulation when we have α vary and β fixed

$$\max \sum_{l=1}^{L} \sum_{i=1}^{S} (\alpha_i + \beta I_i) p_{il} x_{il} \quad (15)$$

Subject to constraint (2)-(8) and (13)-(14).

Since ISP wants to get revenue maximization by setting up the prices chargeable for a base price and quality premium and QoS level to recover cost and to enable the users to choose services based on their preferences like stated in (1). Constraint (2) shows that the required capacity of service does not exceed the network capacity reserved. Constraint (3) explains that required capacity cannot be greater than the network capacity C in link l. Constraint (4) guarantee that network capacity has different location for each service that lies between 0 and 1 (5). Constraint (6) explains that QoS level for each service is between the prescribed range set up by ISP. Constraint (7) shows that users applying the service are nonnegative and cannot be greater than the highest possible users determined by service provider. Constraint (8) states that the number of users should be positive integers. Objective function (9) explains that ISP wants to get revenue maximization by setting up the prices chargeable for a base price and quality premium and QoS level to recover cost and to enable the users to choose services based on their preferences. Constraint (10) explains that quality premium has different level for each service which is at least the same level or lower level. Constraint (11) states that value of quality premium lies between two prescribed values. ISP wants to get revenue maximization by setting up the prices chargeable for a base price and quality premium and QoS level to recover cost and to enable the users to choose services based on their preferences like stated in (12). Constraint (13) explains that the summation of base cost and quality premium has different level for each service which is at least the same level or lower level. Constraint (14) shows that the base price should lie between prescribed base price set up by ISP. ISP wants to get revenue maximization by setting up the prices chargeable for a base price and quality premium and QoS level to recover cost and to enable the users to choose services based on their preferences as stated in objective function (15).

IV. OPTIMAL SOLUTION

Will solve the model by using LINGO 13.0 then

1. Case 1: α and β as constant by modifying the QoS level so we divide Case 1 into three sub cases.
2. Case 2: α as constant and β as a variable by modifying the quality premium and QoS level so we divide Case 2 into 9 sub cases.
3. Case 3: α as variable and β as constant so we divide Case 4 into 9 cases
4. Case 4: α and β as variables by modifying the base price, quality premium and QoS level so we divide Case 3 into 27 sub cases.

We have total of 48 sub cases. According to the results of LINGO 13.0 we have two solutions of sub case from each case as follows. We also compare out results with the result previously discussed by [18].

Table III to Tabel VI below present the optimal solution of our four cases. Tabel III shows that in Case 1: α and β as constant, we obtain the highest optimal solution of 750.445. Total highest capacity used is 7965 kbps or 79.65% of total capacity available. The highest profit is obtained in our model with I_i<I_{i-1} and model proposed by [18] with capacity used of 7950 kbps or 79.50%.

TABLE III
CASE 1 SOLUTION WITH α AND β AS CONSTANTS

i	Model [18]		I_i=I_{i-1}		I_i<I_{i-1}	
	Link 1					
	C Used	Profit	C Used	Profit	C Used	Profit
1	600	15.3	210	15.105	600	15.3
2	3375	227.025	2625	226.575	3375	227.025
3	0	75	1155	75.525	0	75
	Link 2					
1	600	30.6	600	30.6	600	30.6
2	3375	282.52	3375	282.52	3375	282.52
3	0	120	0	120	0	120
∑	7950	750.445	7965	750.325	7950	750.445

TABLE IV
CASE 2 SOLUTION WITH α AS CONSTANT AND $\beta_i = \beta_{i-1}$

i	Model [18]		I_i=I_{i-1}		I_i<I_{i-1}	
	Link 1					
	C Used	Profit	C Used	Profit	C Used	Profit
1	210	23.4	210	23.4	600	39
2	2625	351	2625	351	3375	387
3	1155	117	1155	117	0	75
	Link 2					
1	210	46.8	210	46.8	210	46.8
2	2625	436.8	2625	436.8	2625	436.8
3	1155	187.2	1155	187.2	1155	187.2
∑	7980	1162.2	7980	1162.2	7965	1171.8

Table IV depicts the solution of case 2. We obtain the highest optimal solution of 1171.8 with the highest capacity used is 7965 kbps or 79.65% of total capacity available. The highest profit is obtained in our model with I_i<I_{i-1} and model proposed by [18]. In Table V, The highest profit is 1197.445 which is obtained in our model with I_i<I_{i-1} and capacity used of 7950 kbps or 79.50%. Table VI shows that the highest profit of 1627.6 is obtained in our model with I_i<I_{i-1} with capacity used of 7950 kbps or 79.50%.

TABLE V
CASE 3 SOLUTION WITH α AS $\alpha_i = \alpha_{i-1}$ AND β AS A CONSTANT

i	Model [18]		I_i=I_{i-1}		I_i<I_{i-1}	
	Link 1					
	C Used	Profit	C Used	Profit	C Used	Profit
1	210	24.105	210	24.105	600	24.3
2	2625	361.575	2625	361.575	3375	362.025
3	1155	120.525	1155	120.525	0	120
	Link 2					
1	210	48.21	210	48.21	600	48.6
2	2625	449.96	2625	449.96	3375	450.52
3	1155	192.84	1155	192.84	0	192
∑	7980	1197.215	7980	1197.215	7950	1197.445

TABLE VI
CASE 4 SOLUTION WITH α AS $\alpha_i = \alpha_{i-1}$ AND β AS $\beta_i = \beta_{i-1}$

i	Model [18]		I_i=I_{i-1}		I_i<I_{i-1}	
	Link 1					
	C Used	Profit	C Used	Profit	C Used	Profit
1	210	32.4	210	32.4	600	48
2	2625	486	2625	486	3375	522
3	1155	162	1155	162	0	120
	Link 2					
1	210	64.8	210	64.8	600	96
2	2625	604.8	2625	604.8	3375	649.6
3	1155	259.2	1155	259.2	0	192
∑	7980	1609.2	7980	1609.2	7950	1627.6

In all cases, the requirement for QoS level for service i should be less than service i-1 scheme yield the highest optimal solution. From all 4 cases, the highest optimal solution will be case 4 when we set up base price and quality premium as variables. It means ISP is able to compete the market and promote certain services if ISP varies the base price and quality premium and set up the QoS level of $I_i < I_{i-1}$.

V. Conclusions

We have shown that by considering new parameters, more decision variables and constraints, we obtain better profit maximization. The cases shown above basically are ISP strategy to vary its preference to achieve their goals. ISP is able to adopt the cases to suit their goals. The highest maximum profit that can be obtained by ISP is by setting up the base price and quality premium to be varied and also setting up $I_i < I_{i-1}$.

However, like stated in [11, 14] since it is more theoretical point of view and assumptions, we limit our result only static result in data changes, and cost preference is just based on our discrete data.

Further research should address more generalization of the model to also consider numerous services offered or generalization of more services

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