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Quasi Linear Utility Function Based-Wireless Internet Incentive-Pricing Models

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Quasi Linear Utility Function Based-Wireless Internet Incentive-Pricing Models

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Abstract - **In the internet pricing scheme, internet incentive pricing is used to optimize the price of online services. The desire to pay is one of the prerequisites for customers to subscribe to the service in this study, hence diverse consumers are used. With the growing demand for internet services, service providers are competing to deliver the finest service possible in order to improve service quality and attract customers. Then, using a combination of bundling, a quasi linear utility function, high and low demand users, reverse charging, and a two-part tariff pricing system, this study aims to find the best model and solution for an enhanced internet incentive-pricing model. The computation used to test the model using real data reveals that in this scenario β as a parameter and γ as a parameter with two-part tariff-pricing scheme when FG_{xy} increases and α increases, as numerical example from local data shows an incentive value of IDR 797.55 / kbps. This result shows that an enhanced incentive-pricing strategy has benefited ISPs.**

Keywords—: incentives, bundling, reverse charging, Quasi Linear utility function, multiple QoS, mixed integer nonlinear programming (MINLP).

I. INTRODUCTION

The internet is a computer-based channel for searching for information that can be accessed by anyone in the globe. The usage of computers in the future may dominate human employment and perhaps destroy human computing talents; as a result, internet users will have access to a growing number of internet facilities and services.

The internet is provided by a service provider known as an internet service provider (ISP)[1], [2]. ISPs are also often referred to as internet service provider companies. The number of internet users will not decrease but will continue to increase; therefore, ISPs must take advantage of ever-developing information technology to increase their ability to face competition and to provide optimal services to customers. To keep the available services good and quality, ISP provides Quality of Service (QoS)[3]–[5]. According to Puspita et al.[6], there are several reasons why QoS are needed as follows: to maximize the use of existing networks, to give priority to applications that are critical to the network, and also to improve performance for applications, sensitive to delay[7] such as video and voice[8], [9].

Bundling is a marketing strategy where two or more products are sold in one package at a special price[10]–[14]. Bundling pricing[15]–[17] is the price of selling two or more products in one package but at a price lower than the price per unit product.

IRC (Internet Reverse Charging) means that the ISP will adjust 3G and 4G networks appropriately in their use and according to the conditions and location of the user [18], [19]. The reverse charging method only focuses in one direction, namely between the ISP and its users. Meanwhile, other ISPs cannot perform reverse charging. Reverse charging is a scheme that is formed and adapted to suit user demands or desires, by combining incentive mechanisms to gain user satisfaction and reduce congestion[20].

One way to measure the desires to pay of the consumers[21] is by utilizing the utility function[22]–[24]. ISP can seek for the amount of preferences of the user by choosing the perfect utility function that can measure linearity and nonlinearity of satisfaction of consumers through utility function called quasi linear utility function[16], [25], [26].

Utility function also deals with users who would like to subscribe the network. Previous research already described the homogeneous users which are users who has the same preferences on everything in network. For real network, it is impossible to have such condition. Therefore, seeking for real consumer as heterogeneous consumers seems to be more realistic to be discussed.

Incentives[27], [28] can be interpreted as a mean to encourage or motivate either material or other things. In the discussion of incentive pricing, ISPs can use incentives to give to consumers which can reduce congestion[29]–[31]. So that the ISP can optimize profits [32] and services to its users.

Then, this study seeks to develop the updated model as the Mixed Integer Nonlinear Programming model (MINLP)[33], [34] by updating the improved reverse charging model previously proposed by Puspita et al.[35]. Those models which has transformed into previously proposed of improved internet incentive pricing scheme[20], to be updated improved incentive pricing scheme by considering the bundling scheme in the model to be formed as an internet incentive pricing scheme, with two part tariff[21] pricing scheme and quasi linear utility function for heterogeneous users.

Scarce research in formulating the model of updated improved incentive pricing involving bundling strategy for heterogeneous consumers trigger the deep research about those possibility in finding new design in terms of updated model involving those schemes as mentioned before. The new research MINLP focuses on problems in determining the optimal solution of an objective function, which is limited by one or more constraint, will be main contribution to this research.

II. Research Method

In this study, calculations were carried out using an optimization solution, MINLP by simulating the form of an optimization model using LINGO 13.0[36] software which is limited by the variables on the use of consumer links ($x = 1, 2$) and service class ($y = 1, 2$). This study uses a combination of bundling, improved reverse charging, high demand and low demand consumers with quasi linear utility functions, and the two-part tariff pricing scheme. The data is used for evaluating that the model designed was capable to obtain better solution than the original model. The data used is digilib traffic data from January 1-January 31, 2020. The range of data are chosen is for usage purpose only and only for proving that the model can be used to solve according to data given. The steps to complete an improved incentive pricing model are as follows:

1. Explain data, parameters and variables used that are displayed in Table I and Table II. The parameters consist of all values already set and prescribed according to traffic data and by the network. Decision variables will be determined during the process of modelling to reach the objective of the ISP in gaining the revenue. Data for numerical results is obtained from local server data that comprised bandwidth traffic for one month that is explained in Table III.
2. Establish an updated improved internet incentive pricing model using a combination of bundling, improved reverse charging. High demand and low demand consumers with quasi linear utility functions, as well as two part tariff pricing scheme.
3. Complete of an improved internet incentive pricing model solution using LINGO 13.0.
4. Compare the optimal solution of the improved internet incentive pricing model with an updated improved internet incentive pricing model.
5. Validate the model by those data utilization.
6. Analyze the results obtained.

As Fig. 1 shows, design process for the upgraded incentive model based on quasi linear function is displayed as follows.

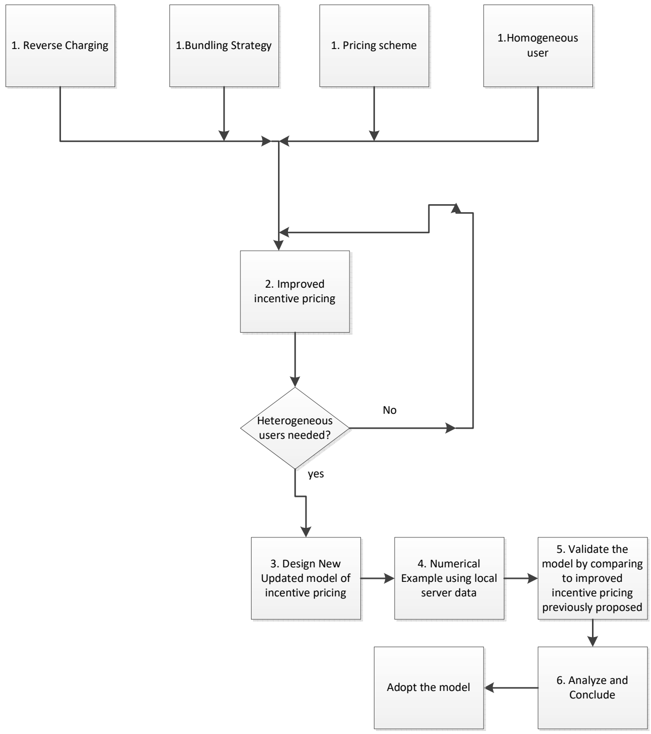

Figure 1. Design Process of Proposed Updated Improved Incentive Pricing Scheme

III. Result and Analysis

Variable's definitions are described in Table I, parameter definitions are described in Table II. Basically, Table I shows the design variables to be assigned into the model. Those values will show how much ISP will gain in the objective function of the model. Table II is determined by having some knowledge about the network including the capacity of the network, cost incurred by customers set up by ISP, base price or quality premium that ISP set. Table III shows the parameter values obtained from the traffic data that consist of inbound and outbound data. Then, data is classified into off peak and peak hours to get the average per day and accumulation for 30 days.

Those parameters and variables chosen are based on model designed on reverse charging scheme [37], bundling strategy [10] for internet pricing and also pricing strategy for homogeneous users[21].

TABLE I. VARIABLES OF UPDATED IMPROVED INTERNET INCENTIVE PRICING

Variable	
F_y	The price set for each bundle of services *i*
O_x	The benefits of using it for the *i*-th consumer
A_{xy}	Value 1 if consumer *i* chooses bundle in service *j* and has value 0 if customer *i* does not choose bundle in service *j*
B_y	Value 1 if the service provider offers a bundle of service *j* and a value 0 if the service provider does not offer the bundle of service *j*
A_x	The level of consumption of consumers *i* at peak hour services
B_x	The level of consumption of consumers *i* on off - peak service
C_x	If a consumer chooses to participate in the program, they will receive a score of 1, and if they do not, they will receive a score of 0.
A_x	Consumer *i*'s greatest usage level during peak hour services
B_x	The maximum consumption level of consumer *i* at off-peak service
FG_{xy}	Changes in costs during changes in QoS (IDR)
FH_{xy}	Base fee for a connection with user *i* and class *j*
Z_a	The linearity factor
j_{xy}	Linear cost factor in user *i* and class *j*
W_z	Traffic content
a	The amount by which the QoS value has increased or decreased.
H	Defined linear parameters

Next step, create an updated improved model of internet incentive pricing. The model has the purpose to maximize ISP' goal by considering the bundling strategy $(F_y - H_y)A_{xy}$ which deals with the willingness of users to join the strategy to be introduced with the price subscribed by customers $(F_A A_1 + F_A A_2 + F_B B_1 + F_B B_2 + FC_1 + FC_2)$ and fee for connecting with QoS that comprises basic price, quality premium and quality index $(\sum_{x=1}^{2}\sum_{y=1}^{2}\left((FU_{xy} + FG_{xy}\right) + (\beta + \gamma X_X) + F_{xy}A_{xy}))$.

A. Case 1: β and γ Parameters

Base price as parameter is intended to enable ISP to at least does not fall into bankruptcy for not having users to subscribe the scheme. Meanwhile, the quality premium as parameter means that ISP would like enable users to select some classes according to users' preferences. Then, the case will be divided into sub-cases as follows.

Sub-Case a: FG_{xy} increases, a increases.

Sub-Case a, dealing with the increase changes in cost during changes in QoS with the amount of increase in QoS value is detected. Then, the updated model will be as follows.

TABLE II. PARAMETERS OF UPDATED IMPROVED INTERNET PRICING SCHEME

Parameter	
FU_{xy}	Fees for connecting with the available QoS
Q	If adding more than one service bundle to the menu, the cost will be marginal.
H_y	Costs in bundling each service *j*
R_{xy}	For each of the *j*-favorite services, the price of the *i*-th customer order.
U_{xy}	Each *i*-th customer's total order price for each *j*-th favorite service
F	Costs that user will incur as a result of using the service
Fa	During peak hours, the service provider sets the unit pricing.
Fb	During off-peak hours, the service provider sets the unit pricing.
$jA + Bh$	Peak and off-peak consumption rates are represented by a consumer utility function.
A_x	Consumer *i*'s greatest usage level during peak hour services
B_x	The maximum consumption level of consumer *i* at off-peak service
j_1	Service constant rush hour heterogeneous consumers of high usage levels
j_2	Service constant rush hour heterogeneous consumers of low-level usage
h_1	Service constant off-peak hours of heterogeneous consumers of high usage groups
h_2	Service constant off-peak hours of heterogeneous consumers of low usage groups
β	Each service is priced based on the time it takes to complete it.
γ	Every service is of the highest quality.
I	The total capacity discovered on the connection
F_{xy}	Service starter price *i* on link *j*
q_x	Minimum Service Quality of Service (QoS) *i*
k_x	The number of people who utilize the service *i*
Gh_{xy}	The nominal value of the QoS attribute in the operator's network (kbps)
e_{xl}	Required capacity for service *i* on link *j*
m	The service provider has established a value limit for $\hat{a}_{ij}$
l	The maximum traffic load that $\hat{T}_i$ can handle.
n	Tl's minimum allowable traffic load
p	The service provider has established a value limit for $\hat{a}_{ij}$
X_x	For service *i*, a minimum basis pricing is required.
h_x	The service *i* must have a minimum basic pricing.
p_x	Maximum premium quality for *i* service
i_x	Minimum premium quality for service *i*

TABLE III. VALUES OF PARAMETERS OF UPDATED IMPROVED INTERNET INCENTIVE PRICING

Par	Value	Par	Value	Par	Value
A_1	48429.72	F_{22}	15	h_1	2
A_2	34738.76	G_{hxy}	2000	h_2	2
B_1	41193.55	m_{11}	0.05	FU_{11}	0.5
B_2	19170.73	m_{12}	0.06	FU_{12}	0.6
β	0.1	m_{21}	0.07	FU_{21}	0.4
γ	0.5	m_{22}	0.08	FU_{22}	0.7
I	350000	p_{11}	0.15	F_{11}	15
H_1	300	p_{12}	0.14	F_{12}	15
H_2	500	p_{21}	0.13	F_{21}	15
Q	200	p_{22}	0.12	i_1	0
R_{11}	500	n	50	i_2	0
R_{12}	800	l	1000	e_{11}	18.18
R_{21}	600	q_1	0.01	e_{12}	18.18
R_{22}	900	q_2	0.01	e_{21}	17.37
j_1	3	k_1	10	e_{22}	17.37
j_2	3	k_2	10	p_1	1
				p_2	1

Max $U = \sum_{x=1}^{2} \sum_{y=1}^{2} (F_y - H_y) A_{xy} - \sum_{y=1}^{2} QB_y - (3A_1 + B_1^2) - (3A_2 + B_2^2) + F_A A_1 + F_A A_2 + F_B B_1 + F_B B_2 + FC_1 + FC_2 + \sum_x^2 \sum_y^2 \left((FU_{xy} + FG_{xy}) + (\beta + \gamma X_x) + F_{xy} A_{xy}\right)$ (1)

Subject to:

$O_x \geq (U_{xy} - F_y) B_y$ (1.1)

$O_x = \sum_{y=1}^{2} (U_{xy} - F_y)$ (1.2)

$(U_{xy} - F_y) A_{xy} \geq 0$ (1.3)

$\sum_{y=1}^{2} A_{xy} \leq 1$ (1.4)

$A_{xy} \leq B_y$ (1.5)

$O_x \geq 0.1$ (1.6)

$F_x \geq 0.1$ (1.7)

$A_x \leq A_x C_x$ (1.8)

$B_x \leq B_x C_x$ (1.9)

$(3A_1 + B_1^2) - (3A_2 + B_2^2) - F_A A_1 - F_A A_2 - F_B B_1 - F_B B_2 - FC_1 - FC_2 \geq 0$ (1.10)

$C_x \in \{0,1\}$ (1.11)

$X_x e_{xy} a_{xy} \leq j_x I$ (1.12)

$\sum_{x=1}^{2} \sum_{y=1}^{2} X_x e_{xy} a_{xy} \leq j_x I$ (1.13)

$j_1 + j_2 = 1$ (1.14)

$0 \leq j_x \leq 1$ (1.15)

$0 \leq q_x \leq X_x \leq 1$ (1.16)

$0 \leq A_{xy} \leq k_x$ (1.17)

$FG_{xy} = \left(1 + \frac{a}{G_{hxy}}\right) FH_{xy} Z_a$ (1.18)

$FH_{xy} = j_{xy}(r - r^{-aH})^{W_z}/100$ (1.19)

$Z_a = (r - r^{-aH})$ (1.20)

$m \leq j_{xy} \leq p$ (1.21)

$n \leq W_z \leq l$ (1.22)

$0 \leq a \leq 1$ (1.23)

$0.8 \leq H \leq 1.07$ (1.24)

$j = 1$ (1.25)

Basically, what the ISP intend to do is to gain revenue by taking into consideration of bundling strategy that involving quasi linear utility function $(3A_2 + B_2^2)$ and price for users in subscribing the pricing schemes as stated in Eq. (1) which is other different model proposed in[20] where the model used Cobb-Douglas utility function.

Sub-Case b: FG_{xy} increases, a decreases

For *Sub-Case b*, the goal is the same as case a, except for having the decrease in the QoS value. The problem is to maximize the Eq. (1) followed by Eq. (1.1) to Eq. (1.17) and adding a new constraint,

$FG_{xy} = \left(1 - \frac{a}{G_{hxy}}\right) FH_{xy} Z_a$ (1.26)

then proceed with Eq. (1.19) to Eq. (1.26).

B. *Case 2: β as parameter and γ as variable*

In Case 2, the model updated is designed to have base price as parameter to at least are able to recover the cost and quality premium as variable to have goal in choosing certain service to be promoted by ISP .Then, the sub-cases will be as follows.

Sub-Case a: FG_{xy} increases and a increases.

The objective function will be as follows.

Max $U = \sum_{x=1}^{2} \sum_{y=1}^{2} (F_y - H_y) A_{xy} - \sum_{y=1}^{2} QB_y - (3A_1 + B_1^2) - (3A_2 + B_2^2) + F_A A_1 + F_A A_2 + F_B B_1 + F_B B_2 + FC_1 + FC_2 + \sum_x^2 \sum_y^2 \left((FU_{xy} + FG_{xy}) + (\beta + \gamma X_x) + F_{xy} A_{xy}\right)$ (2)

With Eq. (1.1) -Eq. (1.26) and also the constraints as follows.

$\gamma_2 X_2 \geq \gamma_1 X_1$ (2.1)

$X_x \leq \gamma_x \leq h_x$ (2.2)

Since variation in quality premium to promote certain service in network, then the Eq. (2) holds.

Sub-Case b: FG_{xy} increases, a decreases.

The goal in ISP' strategy is to maximize the objective function (2) followed by Eq. (1.1) to Eq. (1.17), followed by Eq. (1.26) and ending with Eq. (1.19) to Eq. (1.25) and Eq. (2.1) to Eq. (2.2).

Table IV-VI basically shows the solver status when setting up the scheme with base price and quality premium as parameters as Table IV shows. Meanwhile, while setting up base price as parameter and quality premium as variable, the solution is obtained in Table V and lastly, Table VI shows that solutions in varying FG_{xy} and a.

TABLE IV. SOLUTIONS FOR AN UPDATED IMPROVED INTERNET PRICING SCHEME WITH TRAFFIC DATA WHEN β AND γ AS PARAMETERS

Solver Status	**Case β and γ as Parameters**	
	FG_{xy} increase a increase	FG_{xy} increase a decrease
Model Class	MINLP	MINLP
Objective	1612.48	1612.45
Iterations	157	157
GMU (K)	48	48
ER (Sec)	1	0

TABLE V. SOLUTIONS FOR AN UPDATED IMPROVED INTERNET PRICING SCHEME WITH TRAFFIC DATA WHEN β AS PARAMETERS AND γ AS VARIABLE

Solver Status	**Case β as Parameter and γ as Variable**	
	FG_{xy} increase a increase	FG_{xy} increase a decrease
Model Class	MINLP	MINLP
Objective	1537.48	1537.45
Iterations	184	184
GMU (K)	50	50
ER (Sec)	1	0

TABLE VI. IMPROVED INTERNET INCENTIVE PRICING MODEL SOLUTIONS

Solver Status	Internet Incentive Pricing Case	
	FG_{xy} increase a increase	FG_{xy} increase a decrease
Model Class	MINLP	MINLP
Objective	814.93	814.89
Iterations	629	631
GMU (K)	47	47
ER (Sec)	1	1

For showing more clearer differences on previous model and proposed model, Fig. 2 dan Fig. 3 will displayed those differences that explains that all updated models yield higher profit for ISP.

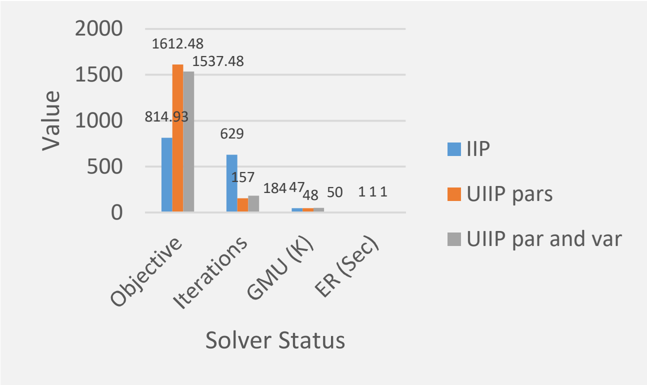

FIGURE 2. COMPARISON AMONG UPDATED IMPROVED INCENTIVE PRICING (UIIP) WITH β AND γ AS PARAMETERS AND β AS VARIABLE AND γ AS PARAMETER AND IMPROVED INCENTIVE PRICING (IIP) WHEN FG_{xy} INCREASES a INCREASES

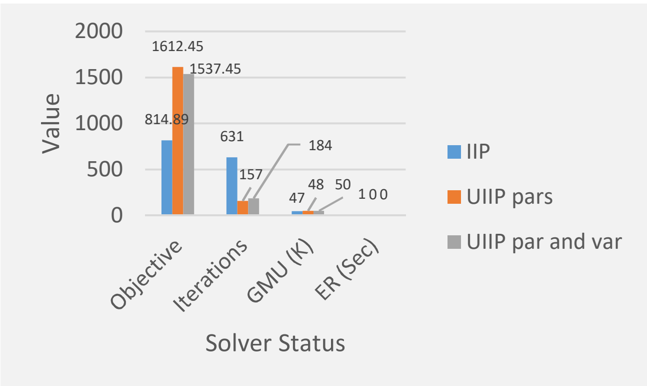

FIGURE 3 COMPARISON AMONG UPDATED IMPROVED INCENTIVE PRICING (UIIP) WITH β AND γ AS PARAMETERS AND β AS VARIABLE AND γ AS PARAMETER AND IMPROVED INCENTIVE PRICING (IIP) WHEN FG_{xy} INCREASES a DECREASES

For validating the model to state that design model is better than the previous model is by comparing the model with local data server that stated that all new updated incentive pricing model has higher revenue compared with improved incentive pricing previously discussed by Puspita et al [20]. The other design variables show the same values with previous variables, but the differences are due to the utility function used combined with bundling strategy. The QoS measurement achieved was also the same values for improved model and updated improved model. It means that with the same limitations occurs in networks, but having different goal, will yield better and different results.

The utilization of utility function can enhance the higher profit gained by ISPs. Utility function of quasi linear has advantage that consumption depends only on prices set up not only on income, that is the best strategy that can be adopted for users who wants to minimize its willingness to pay the service.

On the other hand, the strategy of bundling where chosen due to its advantage to allow ISP to collect more services to be offered to potential customers. Then to sum up, the choice of the proposed model seem to have better profit for ISP while gain customer's trust in applying the network.

IV. CONCLUDING REMARKS

The optimal solution is obtained from an updated improved internet incentive pricing scheme for heterogeneous consumers based on willingness to pay as much as 1612.48 / kbps when FG_{xy} increases and a increases. The incentive value is the difference from the optimal solution of the improved incentive pricing model with the optimal solution for internet incentive pricing, with values of 1612.48 / kbps and 814.93/kbps respectively. Therefore, the incentive value obtained is 797.55 / kbps. So, by using an improved incentive pricing model, the ISP gets a bigger profit.

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