

# END-TO-END DELAY QOS ATTRIBUTE-BASED BUNDLING STRAEGTI OF WIRELESS IMPROVED REVERSE CHARGING NETWORK PRICING MODEL

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## End-to-End Delay QoS Attribute-Based Bundling Strategy of Wireless Improved Reverse Charging Network Pricing Model

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### Abstract

In this article, a multi-link internet reverse charging (IRC) scheme model in a multi-service network with the addition of a *bundling* strategy is proposed. Reverse charging schemes in multi-link and multi-service networks are rarely discussed in previous studies. This pricing scheme is designed with the aim of maximizing service provider profits by minimizing internet usage costs. The basic cost and satisfaction level of the service provided by the ISP (Internet Service Provider) is focused on this effort. The model formed in this study is a *Mixed Integer Non-Linear Programming* (MINLP) model that is completed using software LINGO 13.0. This problem comprises two cases, when  $\alpha$  (base price) case as a parameter and  $\beta$  (quality premium) as a parameter or variable with sub-cases  $PQ_{ij}$  (the changes on cost with changes on QoS) increases in *usage based* pricing schemes. Thus, the results obtained can be a consideration for ISPs in determining the price of services that can support an ISP. The updated IRC model provides a more optimal solution than the original IRC model.

### Keywords

pricing scheme, LINGO 13.0, ISP, bundling, end-to-end delay

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### 1. INTRODUCTION

Internet Service Provider (ISP) ( Petrova (2003) ; Wu et al. (2010) ) competes in providing the best internet service to achieve customer satisfaction. According to Stremersch and Tellis (2002) and Yang (2004) high-speed data transmission requires an application to connect consumers to the internet which will allow different quality QoS ( Shalunov and Teitelbaum (2003) ; Kolhar et al. (2016) ) networks. By providing the best quality service ( Bandung and Sumardi (2016) ; Fang et al. (2018) ; Puspita FM and Taib BM (2013) ), ISP can get the maximum benefit by providing the best quality information to serve users.

Internet Reverse Charging (IRC) (Puspita et al., 2019) model is a model that introduces service quality and speed of user access by focusing on *charging* is only done by one ISP to ISP customers so do not allow others to do the reverse charging. The IRC model focuses on switching 3G and 4G ( Fagbohun (2014) ; Pagani and Fine (2008) ) networks when hosting. Charging schemes can allow ISPs to benefit from their own customers and not from other customers (Blake et al., 1998).

Research by (Puspita et al., 2020) discussed the Improved IRC model of the wireless network pricing scheme on the QoS end-to-end delay attribute with restrictions on multi-link networks

and service classes by making it easy for ISPs to set basic price ( $\alpha$ ) and quality premium ( $\beta$ ), and it can be proven strongly that the ISP will get the highest profit. According to Sain and Herpers (2003), a multi-link network ( Puspita et al. (2015) ; Odarchenko et al. (2018) ) is shown to carry a wide variety of services and applications with different characteristics and a variety of times. The end-to-end delay attribute refers to the time it takes for a packet to be sent across the network from source to destination.

ISPs are usually faced with the problem of determining the right model in offering information service products quickly and profitably. To adjust the price, the ISP should understand the quality of service that can affect the user's need to use ISP products. The strategy carried out by ISPs in offering a product usually uses a bundle pricing strategy ( Wu et al. (2008) ; Venkatesh (2017) ; Puspita et al. (2015) ) to attract consumer interest and this strategy is considered to be able to get the maximum benefit from some of the products offered (Venkatesh, 2017). Error in set of information services product strategy may have an impact on his interest is not the customer to choose a product *bundling* offered.

This research is based on the previous IRC model (Puspita et al., 2019) which was updated with the addition of a *bundling* problem optimization model ( Wu et al. (2008);Puspita et al. (2016)

) to maximize income for service providers with a usage-based pricing scheme. The updated model involves a utility function (Kuo and Liao (2005);Merayo Álvarez et al. (2017)) in consideration of customer satisfaction in each service and product sales using a *usage-based* pricing scheme (Wu and Banker, 2010) with the hope that service providers are able to compete in the market and consider customer satisfaction. The utility function (Kuo and Liao (2005); Merayo Álvarez et al. (2017); Odlyzko (1998)) used in this model is proposed by Yang et al. (2004) because it can meet customer satisfaction and is easy to analyze for homogeneity and heterogeneity which has an impact on price choices (Indrawati et al., 2014).

**2. RESEARCH METHOD**

**2.1 Data**

The data used in this study basically is used for validating the model designed. It is secondary data obtained from a local server in Palembang. The research includes traffic-files data obtained from January 1, 2020 to January 28, 2020. The data contains inbound and outbound bandwidths in bit per second per day for 28 days. Data is divided into two classifications which are bandwidth usage in peak hours and in off peak hours to show the highest consumption consumer level (Indrawati et al., 2014) in using the network both in peak hour and off peak hour.

**2.2 Methods**

The following are the research steps:

1. Data is carried out in one of the local server in Palembang at the beginning of the semester with secondary data for 28 days (1 January 2020-28 January 2020). The data used in this research include data traffic files that is used for validating the model designed.
2. Describe the data that has been grouped based on capacity usage.
3. Describe the parameters and decision variables used in the updated IRC model for bandwidth consumption in the network
4. Determine an updated IRC model for *end-to-end* delay consumption in the network based on 2 cases and 2 sub- cases in a *usage based* pricing scheme .
5. Seek a solution to the updated IR C model in Step 5 using the LINGO 13.0 application software.
6. Analysis of the results obtained.

**3. RESULTS AND DISCUSSION**

**3.1 Original Model**

The IRC model used in this study is based on the model proposed by Puspita et al. (2020) Its objective functions are as follows:

$$\text{Max } R = \sum_{j=1}^2 \sum_{i=1}^2 ((PR_{ij} + PQ_{ij}) + (\alpha + \beta I_i) p_{ij} x_{ij} + \sum_{i=1}^3 \sum_{j=1}^3 (P_j - B_j) T_{ij} - \sum_{j=1}^3 MY_j) \tag{1}$$

Subject to:

$$I_i d_{ij} x_{ij} \leq a_i C$$

$$\begin{aligned} \sum_{i=1}^2 \sum_{j=1}^2 I_i d_{ij} x_{ij} &\leq a_i C \\ \sum_{i=1}^2 a_i &\leq 1, a_i \in \{0, 1\} \\ m_i &\leq I_i \leq 1, m_i \geq 0 \\ 0 &\leq x_{ij} \leq n_i, x_{ij} \geq 0 \\ PQ_{ij} &= \left(1 \pm \frac{x}{350}\right) PB_{ij} Lx \\ PB_{ij} &= a_{ij}(e - e^{-xB}) T_i / 100 \\ Lx &= a(e - e^{-xB}) \\ f &\leq a_{ij} \leq g \\ h &\leq T_i \leq k \\ 0 &\leq x \leq 1 \\ 0.8 &\leq B \leq 1.07 \\ a &= 1 \end{aligned}$$

Then, the model is given the addition of *bundling* problem optimization Wu et al. (2008) and Puspita et al. (2016) where the parameters and variables are given in Table 1 and Table 2, respectively. Its objective functions are as follows:

Maxs

$$R = \sum_{i=1}^3 \sum_{j=1}^3 (P_j - B_j) X_{ij} - \sum_{j=1}^3 MY_j \tag{2}$$

$$S_i \geq (R_{ij} - P_j) Y_j, i = 1, \dots, I; j = 1, \dots, J$$

$$S_i = \sum_{j=1}^J (R_{ij} - P_j) Y_j, i = 1, \dots, I; j = 1, \dots, J$$

$$(R_{ij} - P_j) X_{ij} \geq 0, i = 1, \dots, I; j = 1, \dots, J$$

$$\sum_{j=1}^J X_{ij} \leq 1, i = 1, \dots, I$$

$$X_{ij} \leq Y_j, i = 1, \dots, I; j = 1, \dots, J$$

$$S_i \geq 0, i = 1, \dots, I$$

$$P_j \geq 0, j = 1, \dots, J$$

$$Y_j = \begin{cases} 1 & \text{for ISP provide bundle in } j \text{ service} \\ 0 & \text{for other wise} \end{cases}$$

$$X_{ij} = \begin{cases} 1 & \text{for choose bundle in } j \text{ service} \\ 0 & \text{for other wise} \end{cases}$$

$$X_i \leq \bar{X}_i Z_i$$

$$Y_i \leq \bar{Y}_i Z_i$$

$$U_i(X_i, Y_i) - P_X X_i - P_Y Y_i - P Z_i \geq 0$$

$$Z_i = 0 \text{ or } 1$$

**Table 1.** Parameters for each Case in IRC model

| Case 1 : $\alpha$ and $\beta$ as Parameters |                                                                                     |
|---------------------------------------------|-------------------------------------------------------------------------------------|
| $\alpha$                                    | : Basic price set by ISP                                                            |
| $\beta$                                     | : for each service there exist the quality premium                                  |
| $C_1$                                       | : Total number of capacity that can be achieved in peak hours                       |
| $C_2$                                       | : Total number of capacity that can be achieved in off-peak hours                   |
| $PR_{ij}$                                   | : Connection cost to the available QoS                                              |
| $p_{ij}$                                    | : User $I'$ price of service on link $j$                                            |
| $m_i$                                       | : Minimum number QoS available for services $i$                                     |
| $n_i$                                       | : Users $I'$ number of service                                                      |
| $d_{ij}$                                    | : Capacity requirement available for service $i$ on link $j$                        |
| $f_i$                                       | : Value ranges that ISP predeterminedt for $a_{ij}$                                 |
| $h$                                         | : The limit of traffic load allowed for $T_l$                                       |
| $k$                                         | : The limit of traffic load allowed for $T_l$                                       |
| $g_i$                                       | : The range of values the service provider has set for $a_{ij}$                     |
| $B_j$                                       | : Cost in bundling each service $j$                                                 |
| $I$                                         | : Potential consumer numbers as a marketing determination                           |
| $J$                                         | : Service number available in ISP                                                   |
| $M$                                         | : Marginal cost if adding greater than one bundle service to menu                   |
| $V_{ik}$                                    | : The price of the $i$ customer order for each $k$ -th favorite service             |
| $R_{ij}$                                    | : The total order price for $i$ th consumer on each $k$ -th preferable service      |
| $P$                                         | : Costs that will be incurred by consumers for following the service                |
| $P_X$                                       | : Price set unit fixed by ISP in peak hours                                         |
| $P_Y$                                       | : Price set unit fixed by ISP in off-peak hours                                     |
| $U_i(X_i, Y_i)$                             | : Consumer utility function $i$ for peak and off-peak consumption levels            |
| $X_i$                                       | : The highest consumption consumer level $i$ in using the program in peak hour      |
| $Y_i$                                       | : The highest consumption consumer level $i$ in using the program in off-peak hours |

**Table 2.** Decision Variables for Each Case in IRC Model

| Case 1 : $\alpha$ dan $\beta$ as Parameter |                                                                                                                    |
|--------------------------------------------|--------------------------------------------------------------------------------------------------------------------|
| $PQ_{ij}$                                  | : The changes on cost with changes on QoS                                                                          |
| $x_{ij}$                                   | : Users applying service $i$ at link $j$                                                                           |
| $PB_{ij}$                                  | : Main fee for having a connection for service $i$ and $j$ link                                                    |
| $a_{ij}$                                   | : Factor of linearity cost in the service $i$ and link $j$                                                         |
| $I_i$                                      | : minimum required for basic price of service $i$                                                                  |
| $T_l$                                      | : Load of traffic                                                                                                  |
| $Lx$                                       | : Factor of linearity                                                                                              |
| $x$                                        | : Increase or decrease parts in QoS value                                                                          |
| $B$                                        | : Set of linear parameter                                                                                          |
| $P_j$                                      | : The price assign for $j$ good bundles                                                                            |
| $S_i$                                      | : Consumer surplus for customer $i$                                                                                |
| $R$                                        | : Function for income                                                                                              |
| $T_{ij}$                                   | : The decision variable stating consumer $i$ whether to choose to join the bundle of $j$ goods or not              |
| $Y_j$                                      | : The decision variable stating consumer $i$ whether to choose to join the bundle of $j$ goods on the menu or not. |
| $Xa_i$                                     | : Service level of consumer consumption in peak hours                                                              |
| $Yb_i$                                     | : Service level of consumer consumption in peak hours                                                              |
| $Z_i$                                      | : Decision variables to be 1 joining the bundle or otherwise                                                       |

### 3.2 Updated Improved Model

The updated model is then designed by adding an Objective Function (1) with an Objective Function (2). Since the model is considered to determine the base cost ( $\alpha$ ) as a parameter and varying the premium quality ( $\beta$ ) as a parameter and a variable in proving the contribution of ISPs in the network, the models are divided into 2 cases, namely Case 1 ( $\alpha$  and  $\beta$  as parameter) and Case 2 ( $\alpha$  as a parameter and  $\beta$  as a variable). Each case is further divided into 2 sub-cases, namely sub-case I  $PQ_{ij}$  and  $x$  increase and sub-case II where  $x$  decreases. The pricing scheme used is *usage based*, namely the internet pricing scheme with a system of how much internet access is used so that much must be paid.

The description of the updated IRC *wireless* network pricing scheme with the QoS *attribute* end-to-end delay and the Cobb-Douglas utility function is described in Table 1-3. Table 1 represents the parameters used for each case in the updated IRC model and describes the symbols or indexes required in each case. Table 2 presents the decision variables used for each case, while Table 3 has applied the parameter values in the model.

In Case 2, when  $\alpha$  as constants and  $\beta$  as a variable based on the case 1 with the exception of  $m_i, n_i, \beta$ , price for service  $i$  and  $b_i$ , a maximum base price required for service  $i$ . After determining the parameters and decision variables in each case, the next step is to determine the value of the parameters used in the model based on the internet usage-based pricing scheme as shown in Table 3 as follows:

where

$a$ : Peak hour service constant

$b$ : Non peak hour service constant

When all the parameters, variable, and the value of the parameter is set, then the model is designed in Eq. (3) - (33). The internet pricing scheme in case 1 and case 2 show that the basic service price ( $\alpha$ ) is chosen as the parameter and the premium quality ( $\beta$ ) is also the parameter. Assuming all consumers have the same level of satisfaction and the same maximum level of users, and assuming that costs during QoS changes are considered to be increasing.

Case 1 :  $\alpha$  and  $\beta$  as constants The objective functions are as follows:

Max

$$R = \sum_{j=1}^2 \sum_{i=1}^2 (PR_{ij} - PQ_{ij}) + (\alpha + \beta I_i) p_{ij} x_{ij} + \sum_{i=1}^3 \sum_{j=1}^3 (P_j - B_j) T_{ij} - \sum_{j=1}^3 M Y_j \tag{3}$$

Based on Eq. (1.1a) then

$$\begin{aligned} I_1(236.1545667)x_{11} &\leq a_1(350000) \\ I_2(236.1545667)x_{11} &\leq a_1(350000) \\ I_1(236.1545667)x_{11} &\leq a_1(370000) \\ I_2(236.1545667)x_{11} &\leq a_1(370000) \end{aligned} \tag{4}$$

**Table 3.** Parameter Value for Each Case on the updated IRC model

| Parameter                        | Value      |
|----------------------------------|------------|
| $PR_{11}$                        | 0.5        |
| $PR_{21}$                        | 0.6        |
| $PR_{12}$                        | 0.7        |
| $PR_{22}$                        | 0.8        |
| $p_{11}, p_{21}, p_{12}, p_{22}$ | 15         |
| $l$                              | 0.1        |
| $\beta$                          | 0.5        |
| $C_1$                            | 350,000    |
| $C_2$                            | 370,000    |
| $m_1$                            | 0.01       |
| $C_2$                            | 0.01       |
| $d_{11}, d_{21}, d_{12}, d_{22}$ | 207530.187 |
| $n_1$                            | 10         |
| $n_2$                            | 10         |
| $V_{11}$                         | 500        |
| $V_{12}$                         | 800        |
| $V_{21}$                         | 600        |
| $V_{22}$                         | 900        |
| $M$                              | 200        |
| $B_1$                            | 300        |
| $B_2$                            | 500        |
| $a$                              | 4          |
| $b$                              | 3          |
| $Xa$                             | 82641.1987 |
| $Yb$                             | 48685.8447 |

Based on Eq. (1.1b) we have

$$\begin{aligned} (I_1 d_{11} x_{11}) + (I_2 d_{21} x_{21}) &\leq (a_1 + a_2) C_1 \\ (I_1 d_{11} x_{11}) + (I_2 d_{21} x_{21}) &\leq (a_1 + a_2) C_2 \end{aligned} \tag{5}$$

Based on Eq. (1.1c) we have

$$a_1 + a_2 = 1 \tag{6}$$

Based on Eq. (1.1d) we have

$$\begin{aligned} 0.01 &\leq I_1 \leq 1 \\ 0.01 &\leq I_2 \leq 1 \end{aligned} \tag{7}$$

Based on Eq. (1.1e) we have

$$\begin{aligned} 0 &\leq x_{11} \leq 30 \\ 0 &\leq x_{21} \leq 30 \\ 0 &\leq x_{12} \leq 30 \\ 0 &\leq x_{22} \leq 30 \end{aligned} \tag{8}$$

**Table 4.** Optimal solutions of the Updated IRC Model in  $\alpha$  and  $\beta$  as constants Cases

| Variable<br>Model Class | $PQ_{ik}$ and $x$ increase | $PQ_{ik}$ increase $x$ decrease |
|-------------------------|----------------------------|---------------------------------|
|                         | MINLP                      | MINLP                           |
| Objective               | 1861.02                    | 1860.85                         |
| $PQ_{11}$               | 8.467065                   | 8.438705                        |
| $PQ_{21}$               | 7.92126                    | 7.876                           |
| $PQ_{12}$               | 7.355456                   | 7.313                           |
| $PQ_{22}$               | 6.789652                   | 6.75                            |
| $x_{11}$                | 0                          | 0                               |
| $x_{21}$                | 0                          | 0                               |
| $x_{12}$                | 0                          | 0                               |
| $x_{22}$                | 10                         | 10                              |
| $PB_{11}$               | 3.56291                    | 3.56291                         |
| $PB_{21}$               | 3.325383                   | 3.325383                        |
| $PB_{12}$               | 3.087855                   | 3.087855                        |
| $PB_{22}$               | 2.850328                   | 2.850328                        |
| $a_{11}$                | 0.15                       | 0.15                            |
| $a_{21}$                | 0.14                       | 0.14                            |
| $a_{12}$                | 0.13                       | 0.13                            |
| $a_{22}$                | 0.12                       | 0.12                            |
| $I_1$                   | 0.505                      | 0.505                           |
| $I_2$                   | 0.1782873                  | 0.1782873                       |
| $B$                     | 1.07                       | 1.07                            |
| $T_1$                   | 1000                       | 1000                            |
| $Lx$                    | 2.375273                   | 2.375273                        |
| $x$                     | 1                          | 1                               |
| $Xa$                    | 0.8635928                  | 0.8635928                       |
| $Yb$                    | 0.6476947                  | 0.6476947                       |
| $P_1$                   | 1299.9                     | 1299.9                          |
| $P_2$                   | 1.1                        | 1.1                             |
| $S_1$                   | 0.1                        | 0.1                             |
| $S_2$                   | 200.1                      | 200.1                           |
| $Z$                     | 1                          | 1                               |
| $T_{11}$                | 1                          | 1                               |
| $T_{21}$                | 0                          | 0                               |
| $T_{12}$                | 1                          | 1                               |
| $T_{22}$                | 0                          | 0                               |
| $Y_1$                   | 1                          | 1                               |
| $Y_2$                   | 0                          | 0                               |



Based on Eq. (1.1f) then

$$\begin{aligned}
 PQ_{11} &= \left(1 \pm \frac{x}{350}\right) PB_{11}Lx \\
 PQ_{21} &= \left(1 \pm \frac{x}{350}\right) PB_{21}Lx \\
 PQ_{12} &= \left(1 \pm \frac{x}{350}\right) PB_{12}Lx \\
 PQ_{22} &= \left(1 \pm \frac{x}{350}\right) PB_{22}Lx
 \end{aligned}
 \tag{9}$$

Based on Eq. (1.1g) then

$$\begin{aligned}
 PB_{11} &= a_{11}(e - e^{-xb})\frac{T_I}{100} \\
 PB_{12} &= a_{12}(e - e^{-xb})\frac{T_I}{100} \\
 PB_{21} &= a_{21}(e - e^{-xb})\frac{T_I}{100} \\
 PB_{22} &= a_{22}(e - e^{-xb})\frac{T_I}{100}
 \end{aligned}
 \tag{10}$$

Based on Eq. (1.1h) then

$$Lx = a(e - e^{-xB}) \tag{11}$$

Based on Eq. (1.1i) then

$$\begin{aligned}
 0.05 &\leq a_{11} \leq 0.11 \\
 0.06 &\leq a_{21} \leq 0.12 \\
 0.07 &\leq a_{12} \leq 0.13 \\
 0.08 &\leq a_{22} \leq 0.14
 \end{aligned}
 \tag{12}$$

Based on Eq. (1.1j) then

$$50 \leq T_I \leq 1000 \tag{13}$$

Based on Eq. (1.1k) then

$$0 \leq x \leq 1 \tag{14}$$

Based on Eq. (1.1l) then

$$0.8 \leq B \leq 1.07 \tag{15}$$

Based on Eq. (1.1m) then

$$a = 1 \tag{16}$$

Based on Eq. (2.2a) then

$$\begin{aligned}
 S_1 &\geq (R_{11} - P_1)Y_1 \\
 S_1 &\geq (R_{12} - P_2)Y_2 \\
 S_2 &\geq (R_{21} - P_1)Y_1 \\
 S_2 &\geq (R_{22} - P_2)Y_2
 \end{aligned}
 \tag{17}$$

Based on Eq. (2.2b) then

$$\begin{aligned}
 S_1 &= (R_{11} - P_1)T_{11} + (R_{12} - P_2)T_{12} \\
 S_2 &= (R_{21} - P_1)T_{21} + (R_{22} - P_2)T_{22}
 \end{aligned}
 \tag{18}$$

Based on Eq. (2.2c) then

$$\begin{aligned}
 (R_{11} - P_1)T_{11} &\geq 0 \\
 (R_{12} - P_2)T_{12} &\geq 0 \\
 (R_{21} - P_1)T_{21} &\geq 0 \\
 (R_{22} - P_2)T_{22} &\geq 0
 \end{aligned}
 \tag{19}$$

Based on Eq. (2.2d) then

$$\begin{aligned}
 T_{11} + T_{12} &\leq 1 \\
 T_{21} + T_{22} &\leq 1
 \end{aligned}
 \tag{20}$$

Based on Eq. (2.2e) then

$$\begin{aligned}
 T_{11} &\geq Y_1 \\
 T_{21} &\geq Y_1 \\
 T_{12} &\geq Y_2 \\
 T_{22} &\geq Y_2
 \end{aligned}
 \tag{21}$$

Based on Eq. (2.2f) we have

$$\begin{aligned}
 S_1 &\geq 0.1 \\
 S_2 &\geq 0.1
 \end{aligned}
 \tag{22}$$

Based on Eq. (2.2g) then

$$\begin{aligned}
 P_1 &\geq 0 \\
 P_2 &\geq 0
 \end{aligned}
 \tag{23}$$

Based on Eq. (2.2h) then

$$T_{11}, T_{21}, T_{12}, T_{22} \in \{0, 1\} \tag{24}$$

Based on Eq. (2.2i) then

$$Y_1; Y_2 \in \{0, 1\} \tag{25}$$

Based on Eq. (2.2j) then

$$Xa \leq (82641.19873)Z \tag{26}$$

Based on Eq. (2.2k) then

$$Yb \leq (48685.84473)Z \tag{27}$$

Based on Eq. (2.2l) then

$$Xa^4 Yb^3 - P_x Xa - P_y Yb - PZ \geq 0 \tag{28}$$

Based on Eq. (2.2m) then

$$Z = 1 \tag{29}$$

Constraint (29) is decision to join the program, so that the consumer had to decide which level of consumption was optimal  $X$  and  $Y$  which could not exceed the limit of the consumer's maximum level of consumption  $\bar{X}$  and  $\bar{Y}$  for Eq. (26) and (2). To maximize the level of customer satisfaction based on the price set by the information service provider, the level of satisfaction must have a non-negative value such as Eq. (28).

Case 2 :  $\alpha$  as Constant and  $\beta$  as Variable

For case 2, the model will be designed with considering  $\alpha$  as constant and  $\beta$  as variable as follows.

Max

$$R = \sum_{j=1}^2 \sum_{i=1}^2 (PR_{ij} - PQ_{ij}) + (\alpha + \beta I_i) p_{ij} x_{ij} + \sum_{i=1}^3 \sum_{j=1}^3 (P_j - B_j) T_{ij} - \sum_{j=1}^3 M Y_j \tag{30}$$

Followed by Constraints (2) to Constraints (29) and the following constraints added, i.e.

$$\begin{aligned} \beta_2 I_2 &\geq \beta_1 I_1 \\ 0.01 &\leq \beta_1 \leq 0.5 \\ 0.01 &\leq \beta_2 \leq 0.5 \end{aligned} \tag{31}$$

To make use of n -pricing scheme usage based, then the added constraints are as follows.

$$P_x > 0; P_y; P = 0 \tag{32}$$

Table 4 is a comparison of the values of the decision variables as Table 2 showed, that are obtained from the wireless internet pricing scheme model for each case in achieving the optimal solution. Based on Table 4, It can be seen that the variable values stated in Table 2, in the *usage based* pricing scheme for sub-case 1 and sub-case 2 are not much different. The value of the variable  $PQ_{ij}$  which states that the change in costs during the change in QoS in case 1 and case 2 is different, the values  $x, T_l, a_{ij}, I_i, x$ , for sub-case 1 and sub-case 2 have the same variable values.

Table 5 is a comparison of the values of the decision variables, again as Table 2 displayed, that are obtained from the wireless internet pricing scheme model for each sub-case in achieving the optimal solution. Based on Table 5 it can be seen that the variable values explained in Table 2, in the usage based pricing scheme for Case 1 and Case 2 are not much different. The value of the variable  $PQ_{ij}$  which states that the changes in costs during the change in QoS in sub-case 1 and sub-case 2 are different, the values  $Lx, T_l, a_{ij}, I_i, x$ , and others, for sub-case 1 and sub-case 2 have the same variable values.

After deciding the optimal solution for each case, analysis the results obtained to compare them with the optimal results

in the original IRC model (Puspita et al., 2019) using the same parameter values and data is conducted.

Case 1: Case  $\alpha$  and  $\beta$  as Parameters Table 6 presents the optimal solution of the two models for Case 1 ( $\alpha$  and  $\beta$  as parameters) with a *usage-based* pricing scheme.

The optimal solution obtained in Table 6 for the IRC model (Puspita et al., 2020) is obtained from the  $PQ_{ij}$  increasing and  $x$  increasing sub - case, which means that there is an increase in cost changes along the changes in QoS and QoS values. Likewise for the model IRC renewed obtained from subcase  $PQ_{ij}$  increasing and  $x$  increasing the use of pricing schemes *usage based*. In this case, with different constraints still at the same values that generate maximum profit ISP that delivers the quality of service and speed of user access.

Based on Table 6 which presents the comparison of the optimal solution of the updated IRC model with an objective value of 1861.02 is greater than the optimal solution of *Improved* IRC with an objective value of 61.25. In this case proved that the model IRC renewed the better to achieve maximum profit ISP that delivers the quality of service and speed of user access with a difference of optimal solutions for 1799.5 kpbs. However, to achieve a better optimal solution, the number of iterations and memory used is quite large.

Case 2 :  $\alpha$  as Parameter and  $\beta$  as Variable Table 7 presents the optimal solution of the two models for Case 1 ( $\alpha$  as a parameter and  $\beta$  as a variable ) with a *usage-based* pricing scheme .

The optimal solution obtained in Table 7 for the IRC model (Puspita et al., 2019) is obtained from the  $PQ_{ij}$  increasing and  $x$  increasing sub - case, which means that there is an increase in cost changes along the changes in QoS and QoS values. Likewise for the model IRC renewed obtained from subcase  $PQ_{ij}$  increasing and  $x$  increasing the use of pricing schemes usage based. In this case, with different constraints still at the same values that generate maximum profit ISP that delivers the quality of service and speed of user access.

Based on Table 7, which presents a comparison of the optimal solution of the updated IRC model with an objective value of 1848.23 is greater than the optimal solution of IRC (Puspita et al., 2020) with an objective value of 48.9034. In this case it is evident that the updated IRC model is better at achieving the maximum ISP benefits that deliver service quality and user access speed with an optimal solution difference of 1799.5966/kpbs. However, to achieve a better optimal solution, the number of iterations and memory used is quite large.

#### 4. CONCLUSIONS

By adding a *bundling* strategy to the IRC *wireless* network pricing scheme , information service providers get more revenue than using the IRC model alone (Puspita et al., 2020) . However, obtaining the maximum income has to be paid with the number of iterations which have an effect on the greatly increased internet resources. In case 2, the objective value obtained is smaller than the objective value in case 1. The number of iterations in case 1 is greater.



For further investigation, it needs to also seek for possibility to add more links to have more real network. It deals with also with the software application abilities to run in many variables and parameters involved.

## 5. ACKNOWLEDGEMENT

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## REFERENCES

- Bandung, Y. and I. Sumardi (2016). Methodology for Characterizing Real-Time Multimedia Quality of Service in Limited Bandwidth Network. *Telkomnika*, **14**(4); 1534
- Blake, S., D. Black, M. Carlson, E. Davies, Z. Wang, and W. Weiss (1998). An architecture for differentiated services
- Fagbohun, O. O. (2014). Comparative studies on 3G, 4G and 5G wireless technology. *IOSR Journal of Electronics and Communication Engineering*, **9**(3); 88–94
- Fang, W., Q. Zhang, M. Liu, Q. Liu, and P. Xia (2018). Earning maximization with quality of charging service guarantee for IoT devices. *IEEE Internet of Things Journal*, **6**(1); 1114–1124
- Indrawati, I., I. Irmeilyana, F. M. Puspita, and M. P. Lestari (2014). Cobb-Douglas Utility Function in Optimizing the Internet Pricing Scheme Model. *TELKOMNIKA (Telecommunication Computing Electronics and Control)*, **12**(1); 227–240
- Kolhar, M., M. M. Abualhaj, and F. Rizwan (2016). QoS design consideration for enterprise and provider's network at ingress and egress router for VoIP protocols. *International Journal of Electrical and Computer Engineering*, **6**(1); 235
- Kuo, W.-H. and W. Liao (2005). Utility-based optimal resource allocation in wireless networks. In *GLOBECOM'05. IEEE Global Telecommunications Conference, 2005.*, volume 6. IEEE, pages 5–pp
- Merayo Álvarez, N., P. Pavón Marino, J. C. Aguado Manzano, R. J. Durán Barroso, F. Burrull i Mestres, M. V. Bueno Delgado, et al. (2017). Fair bandwidth allocation algorithm for PONS based on network utility maximization
- Odarchenko, R., R. Aguiar, B. Altman, and Y. Sulema (2018). Multilink approach for the content delivery in 5G networks. In *2018 International Scientific-Practical Conference Problems of Infocommunications. Science and Technology (PIC S&T)*. IEEE, pages 140–144
- Odlyzko, A. M. (1998). The economics of the Internet: Utility, utilization, pricing, and Quality of Service
- Pagani, M. and C. H. Fine (2008). Value network dynamics in 3G–4G wireless communications: A systems thinking approach to strategic value assessment. *Journal of Business Research*, **61**(11); 1102–1112
- Petrova, K. (2003). ISPs-pricing internet success
- Puspita, F. M., W. Herlina, S. Anggraini, B. Arisha, and Y. Yunita (2019). Improved internet wireless reverse charging models under multi link service network by end-to-end delay QoS attribute. In *2019 International Seminar on Research of Information Technology and Intelligent Systems (ISRITI)*. IEEE, pages 182–187
- Puspita, F. M., D. R. Nur, A. L. Tanjung, J. Silaen, W. Herlina, et al. (2020). Mathematical model of improved reverse charging of wireless internet pricing scheme in servicing multiple QoS. *Journal of Engineering and Scientific Research*, **1**(2); 89–93
- Puspita, F. M., K. Seman, and B. M. Taib (2015). The improved models of internet pricing scheme of multi service multi link networks with various capacity links. In *Advanced Computer and Communication Engineering Technology*. Springer, pages 851–862
- Puspita, F. M., E. Yuliza, and M. Ulfa (2016). The Comparison of Bundle-Pricing Scheme Models Using Quasi-Linear Utility Function. *INSIST*, **1**(1); 12–15
- Puspita FM, S. K. and S. Z. Taib BM (2013). Improved models of internet charging scheme of single bottleneck link in multi QoS networks
- Sain, S. and S. Herpers (2003). Profit maximization in multi service networks-an optimization model. In *ECIS*. Citeseer, pages 1653–1669
- Shalunov, S. and B. Teitelbaum (2003). Quality of service and denial of service. In *Proceedings of the ACM SIGCOMM workshop on Revisiting IP QoS: What have we learned, why do we care?* pages 137–140
- Stremersch, S. and G. J. Tellis (2002). Strategic bundling of products and prices: A new synthesis for marketing. *Journal of marketing*, **66**(1); 55–72
- Venkatesh, R. (2017). The design and pricing of bundles: a review of normative guidelines and practical approaches (2009). Handbook of pricing research in marketing. 232. Amazon EC2 Instance Types (2017). *Amazon EC2 Instance Types*
- Wu, S.-y. and R. Banker (2010). Best pricing strategy for information services. *Journal of the Association for Information Systems*, **11**(6); 1
- Wu, S.-y., L. M. Hitt, P.-y. Chen, and G. Anandalingam (2008). Customized bundle pricing for information goods: A nonlinear mixed-integer programming approach. *Management Science*, **54**(3); 608–622
- Wu, Y., P. H. Hande, H. Kim, M. Chiang, and D. H. Tsang (2010). QoS-revenue tradeoff with time-constrained ISP pricing. In *2010 IEEE 18th International Workshop on Quality of Service (IWQoS)*. IEEE, pages 1–9
- Yang, W. (2004). *Pricing Network Resources for Differentiated Service Networks*. Ph.D. thesis, Georgia Institute of Technology
- Yang, W., H. Owen, and D. M. Blough (2004). A comparison of auction and flat pricing for differentiated service networks. In *2004 IEEE International Conference on Communications (IEEE Cat. No. 04CH37577)*, volume 4. IEEE, pages 2086–2091

**Table 5.** Optimal Solution of the Updated IRC Model in  $\alpha$  as Constant and  $\beta$  as Variable Cases

| Variable Model Class | $PQ_{ik}$ and $x$ increase MINLP | $PQ_{ik}$ increase $x$ decrease MINLP |
|----------------------|----------------------------------|---------------------------------------|
| Objective            | 187.724                          | 18.696                                |
| $PQ_{11}$            | 8.467065                         | 8.438705                              |
| $PQ_{21}$            | 7.92126                          | 7.876125                              |
| $PQ_{12}$            | 7.355456                         | 7.313545                              |
| $PQ_{22}$            | 6.789652                         | 6.750964                              |
| $x_{11}$             | 0.5                              | 0.5                                   |
| $x_{21}$             | 0.5                              | 0.5                                   |
| $x_{12}$             | 0                                | 0                                     |
| $x_{22}$             | 0                                | 0                                     |
| $PB_{11}$            | 0                                | 0                                     |
| $PB_{21}$            | 10                               | 10                                    |
| $PB_{12}$            | 3.56291                          | 3.56291                               |
| $PB_{22}$            | 3.325383                         | 3.325383                              |
| $a_{11}$             | 3.087855                         | 3.087855                              |
| $a_{21}$             | 2.850328                         | 2.850328                              |
| $a_{12}$             | 0.15                             | 0.15                                  |
| $a_{22}$             | 0.14                             | 0.14                                  |
| $I_1$                | 0.13                             | 0.13                                  |
| $I_1$                | 0.12                             | 0.12                                  |
| $B$                  | 1.07                             | 1.07                                  |
| $T_1$                | 1000                             | 1000                                  |
| $Lx$                 | 2.375273                         | 2.375273                              |
| $x$                  | 1                                | 1                                     |
| $Xa$                 | 0.8635929                        | 0.8635929                             |
| $Yb$                 | 0.6476946                        | 0.6476946                             |
| $P_1$                | 1299.9                           | 1299.9                                |
| $P_2$                | 0.1                              | 0.1                                   |
| $S_1$                | 0.1                              | 0.1                                   |
| $S_2$                | 200.1                            | 200.1                                 |
| $Z$                  | 1                                | 1                                     |
| $T_{11}$             | 1                                | 1                                     |
| $T_{21}$             | 0                                | 0                                     |
| $T_{12}$             | 1                                | 1                                     |
| $T_{22}$             | 0                                | 0                                     |
| $Y_1$                | 1                                | 1                                     |
| $Y_2$                | 0                                | 0                                     |

**Table 6.** Comparison of Optimal Solutions between the IRC Model and the Updated IRC Model in the Case of  $\alpha$  and  $\beta$  as Parameters

| Solver Status          | Value Case $\alpha$ dan $\beta$ as Parameter |                          |
|------------------------|----------------------------------------------|--------------------------|
|                        | Model IRC (Puspita, et al., 2019)            | Model IRC updated        |
| Model Class            | MINLP                                        | MINLP                    |
| State                  | Local Optimal                                | Local Optimal            |
| Objective              | 61.525                                       | 1861.02                  |
| Infeasibility          | 0                                            | $9.0955 \times 10^{-14}$ |
| Iterations             | 84                                           | 570                      |
| Extended Solver Status |                                              |                          |
| Solver Type            | Branch and Bound                             | Branch and Bound         |
| Best Objective         | 61.525                                       | 1861.02                  |
| Steps                  | 3                                            | 11                       |
| Update Interval        | 2                                            | 2                        |
| GMU (K)                | 35                                           | 48                       |
| ER (Sec)               | 1                                            | 0                        |

**Table 7.** Comparison of Optimal Solutions between the IRC Model and the Updated IRC Model in  $\alpha$  as a parameter and  $\beta$  as a variable Case

| Solver Status          | Value Case A dan B as Parameter   |                          |
|------------------------|-----------------------------------|--------------------------|
|                        | Model IRC (Puspita, et al., 2019) | Model IRC updated        |
| Model Class            | MINLP                             | MINLP                    |
| State                  | Local Optimal                     | Local Optimal            |
| Objective              | 48.9034                           | 1848.23                  |
| Infeasibility          | 0                                 | $9.0955 \times 10^{-14}$ |
| Iterations             | 44                                | 228                      |
| Extended Solver Status |                                   |                          |
| Solver Type            | Branch and Bound                  | Branch and Bound         |
| Best Objective         | 48.9034                           | 1848.23                  |
| Steps                  | 2                                 | 2                        |
| Update Interval        | 2                                 | 2                        |
| GMU (K)                | 37                                | 49                       |
| ER (Sec)               | 0                                 | 0                        |

# END-TO-END DELAY QOS ATTRIBUTE-BASED BUNDLING STRAEGTI OF WIRELESS IMPROVED REVERSE CHARGING NETWORK PRICING MODEL

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