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- [ ] **Monitoring System in Lora Network Architecture using Smart Gateway in Simple LoRa Protocol**
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Improved internet wireless reverse charging models under multi link service network by end-to-end delay QoS attribute

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***Abstract*—This paper attempts to design the model of Improved Internet Reverse Charging (IRC) which is seldom discussed in some literature. This model is intended to work in multilink wireless internet in multi service Quality of Service (QoS) network that works in some traffics. IRC basically is focused on 3G and 4G turnover while doing the hosting. The models designed are formed in finding the optimal solution of pricing the internet. The mathematical formulation was modelled as Mixed Integer Nonlinear Programming problem (MINLP). IRC based modeling in the consumption of end-to-end delay Quality of Service (QoS) attributes was discussed to obtain the optimal solution. Optimal pricing scheme applied to local data server, using digilib traffic data. Improved IRC models were solved using LINGO 13.0. Basically, the internet network is not in the form of a single link only, but there is also a multilink, it is necessary to develop multilink internet network to match the reality. The results show, by setting up basic price to be varied ISP (Internet Service Provider) has choice to have competition in market and quality premium to be fixed or varied, then ISP choices to customer to select class/service and promote certain service, respectively.**

Keywords—improved internet reverse charging (IRC) model, multilink wireless, Quality of Service (QoS), mixed integer nonlinear programming (MINLP), end –to-end delay

I. Introduction

One of the most desirable in the world of information technology development is through the internet. The need for internet visible from internet users who nearly filled all circles and walks of life both kids, teenagers and even adults. This makes the internet as one of the hot topics discussed in the optimization problem. Several wireless internet pricing schemes on bandwidth, bit error rate (BER), end-to-end delay Quality of Service (QoS) attributes [1] has been discussed by applying the improved model of the C-RAN (Cloud Radio Access Network) [2, 3] on QoS attributes.

Improved internet reverse charging (IRC) model is a model that introduces service quality and speed of user access, where a focus on charging is only done by one Internet Service provider (ISP) to customers that do not allow others to do the charging otherwise[2]. This scheme allows ISP to benefit from their own customers and not customers of other ISP.

Some previous studies on QoS [4, 5] discusses model for the internet based services with different quality levels contain different schemes associated with network QoS and multi-service QoS network[6]. To support this level of advancement of QoS, involvement of a set of quality parameters of data transmission over a communications network that are grouped based on the level of the communication network is critically needed. Most models are considered as Mixed Integer Nonlinear Programming (MINLP) [7, 8]. In this research, the improved IRC is based on the use of internet data that focuses on the use of 3G and 4G networks [9, 10] where ISP will adjust the usage of 3G and 4G precisely to the condition and location of the user. When the user is in a strategic position with the main tower it is most likely that the adjacent distance will affect the usage of the user to the 4G network, and if the user is far enough away from the reach of the 4G network, it will automatically fill in the empty network with 3G networks. Network scheme that can be considered as an optimization model is used to obtain the maximum revenue by using LINGO [11-13]. The model was improved by involving utility functions[14], gains on telcos.

IRC is a schematic formation adapted to fit the environment that meet user demands while maximizing returns ISP and combine incentive mechanism enables ISP to provide incentives for users who are able to reduce congestion and prove effective in gaining user satisfaction. IRC [15] allows ISP to charge other users of other network providers to access user data. IRC, in fact, is seldom discussed as mathematical programming problem. As the

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network improved from single link to multiple link [16-18], single service to multi service[19, 20] from wired to wireless[21-23], it is urgent to discuss deeply about modelling of improved IRC problem in wireless multiple link multi service network. So, basically, the contribution of the research basically focus on the design of new improved models that combine all advantage of reverse charging model in single link, QoS attribute used, cost of change in QoS attribute, and how much change can be determined [10, 24, 25].

II. Research Method

In this paper, the optimal solution pricing scheme on wireless internet in improved IRC model on consumption of end-to-end delay by using application software LINGO 13.0 was conducted. To simulate the calculation, the case on improved IRC models, the necessary data is based on data on the local server for one month (February 27, 2019 - March 27, 2019). The data consists of inbound and outbound application rate End to End Delay in internet access in Palembang. Inbound and outbound data made into 2 link where the division link 1 from at 1:00 p.m. to 11:00 pm while the data link 2 from at 1:00 a.m to 11:00 a.m. To simulate the computation, the case on the IRC model, data is required is based on digilib traffic for one month from local server.

III. Result and Analysis

In this section, IRC models based on end-to-end delay will be described using end-to-end delay multilink attribute for wireless internet network in a multi service network Quality of Service.

Descriptions of pricing scheme of end-to-end delay QoS attribute and improved IRC are described in Table I-III as follows. Table I represents the parameters used for each case on improved IRC models. Table II represents variables used for each case on improved IRC models while in Table III, the parameter set up has been applied in the model.

TABLE I. Parameters for Each Case on Improved IRC for Case 1

Parameter	Case 1: α and β Constants
α	The base price for each service
β	Premium quality for each service
C	The total capacity contained in the link
PR_{ij}	The cost to connect to the QoS provided
p_{ij}	The price of the service *i* at the link *j*
m_i	Minimum QoS for service *i*
n_i	The number of users of the service *i*
d_{ij}	The capacity required to service *i* at the link *j*
f_i	Limit values specified for the service provider a_{ij}
h	Limitation of traffic load that is allowed to Tl
k	Limitation of traffic load that is allowed to Tl
g_i	Limit values specified for the service provider a_{ij}

Case 2, when α as constants and β as variables is based on case 1 with the exception of m_i, n_i, β, added parameter I_i as the base price of the minimum required for service *i* and b_i as the maximum basic price necessary to service *i*. Case 3 with α and β as variables is based on Case 1 and Case 2 with the exception of α and β and the added parameter of c_i of minimum premium for service. Case 4 with α as variables and β as Constants is based on case 1 with the exception of α and added variable of I_i and c_i.

TABLE II. Variables for Each Case on Improved IRC Model

Variables	**Case 1: α and β Constants**
PQ_{ij}	Cost change along with QoS change
x_{ij}	The number of users of the service *i* at link *j*
PB_{ij}	The basic fee for a connection with the service *i* and *j* link
a_{ij}	Linear cost factor in the service *i* and link *j*
I_i	The base price of the minimum required for service *i*
Tl	Traffic load
Lx	Linearity factor
x	Some of the increase or decrease in the value of QoS
B	Parameter Linear set

Case 2 of setting variables is when α as constants and β as variable is based on case 1 with the exception of l_i. The added variable is β_i as the premium quality for service *i*. Next, for case 3 when α and β as variables is based on case 1 and case 2 with the exception of l_i and the added variable will be α_i as the base price for service *i*. Case 4 is based on case 1 with the exception of l_i and the added variable of α_i.

Once the parameters and variables used in the model IRC is determined, the next step is to determine the values of the parameters used in the model IRC, as in Table III. Next, the design of the IRC model has been described into cases of base price (α) and quality premium (β) requirements and for each case of that requirement, sub cases are also introduced to seek for the variability of cost change due to QoS change (PQ_{ij}) and changes in QoS value (x).

TABLE III. Values of QoS parameters in IRC Models

Parameter	Value
The cost of connecting users 1 class 1	0.5
The cost of connecting the two class 1	0.6
The cost of connecting users 1 class 2	0.7
The cost of connecting the two class 2	0.8
The basic price of each service	0.1
The premium quality of each service	0.5
The total capacity contained in the class (C)	350000
Minimum QoS for service 1(m_1)	0.01
Minimum QoS for services 2(m_2)	0.01
Number of users of the service 1(n_1)	10
Number of users of the service 2(n_2)	10

A. Case 1: α and β Constants

The four subcases are explained as follows.

Case a : PQ_{ij} increases and x increases

Max R = (0.5+ PQ_{11}) + ((0.1+0.5I_1)15x_{11}) + (0.6+ PQ_{21}) + ((0.1+0.5I_2)+15x_{21}) + (0.7+ PQ_{12}+((0.1+0.5I_1)15x_{12}) + (0.8+ PQ_{22}) + ((0.1+0.5I_2)15x_{22}) (1)

Subject to

$I_1 d_{11} x_{11} \leq a_1 C_1$

$I_2 d_{21} x_{21} \leq a_2 C_1$

$I_1 d_{12} x_{12} \leq a_1 C_2$

$I_2 d_{22} x_{22} \leq a_2 C_2$ (1a)

$(I_1 d_{11} x_{11}) + (I_2 d_{21} x_{21}) \leq (a_1+a_2) C_1$

$(I_1 d_{12} x_{12}) + (I_2 d_{22} x_{22}) \leq (a_1+a_2) C_2$ (1b)

$a_1+a_2=1$ (1c)

$0.01 \leq I_1 \leq 1$

$0.01 \leq I_2 \leq 1$ (1d)

$0 \leq x_{11} \leq 10$

$0 \leq x_{21} \leq 10$

$0 \leq x_{12} \leq 10$

$0 \leq x_{22} \leq 10$ (1e)

$PQ_{11} = \left(1 + \frac{x}{350}\right) PB_{11} Lx$

$PQ_{21} = \left(1 + \frac{x}{350}\right) PB_{21} Lx$

$PQ_{12} = \left(1 + \frac{x}{350}\right) PB_{12} Lx$

$PQ_{22} = \left(1 + \frac{x}{350}\right) PB_{22} Lx$ (1f)

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

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

$PB_{12} = a_{12}(e - e^{-xB}) \frac{T_l}{100}$

$PB_{22} = a_{11}(e - e^{-xB}) \frac{T_l}{100}$ (1g)

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

(1h)

$0.05 \leq a_{11} \leq 0.15$

$0.06 \leq a_{21} \leq 0.14$

$0.07 \leq a_{12} \leq 0.13$

$0.08 \leq a_{22} \leq 0.12$ (1i)

$50 \leq T_l \leq 1000$ (1j)

$0 \leq x \leq 1$ (1k)

$0.8 \leq B \leq 1.07$ (1l)

$a=1$ (1m)

Case b when PQ_{ij} increases and x decreases will maximize objective function (1) subject to Eq. (1a)-(1e), Constraint (1g)-(1m) and added constraints are as follows.

$PQ_{11} = \left(1 - \frac{x}{350}\right) PB_{11} Lx$

$PQ_{21} = \left(1 - \frac{x}{350}\right) PB_{21} Lx$

$PQ_{12} = \left(1 - \frac{x}{350}\right) PB_{12} Lx$

$PQ_{22} = \left(1 - \frac{x}{350}\right) PB_{22} Lx$ (2a)

Case c when PQ_{ij} decreases and x increases will maximize the objective function (1) subject to constraint (1a)-(1m) and for case d when PQ_{ij} decreases and x decreases the objective function (1) is being maximized subject to Eq. (1a)-(1e), Eq.(1g)-(1m) and Eq. (2a). The solution of IRC for case a when α dan β as parameter is presented in Table IV as follows. As Table III showed, the highest value is achieved when the case of PQ_{ij} increases and x increases but the variable values of 4 cases show almost similar values. User 1 has a choice to choose link 1 or link 2 to fit in their preferences of choosing network.

TABLE IV. OPTIMAL SOLUTION OF IRC USING DIGILIB TRAFFIC WHERE $\boldsymbol{\alpha}$ DAN $\boldsymbol{\beta}$ AS PARAMETER

Var	PQ_{ij} and x increase	PQ_{ij} increases x decreases	PQ_{ij} decreases x increases	PQ_{ij} and x decrease
Model Class	**MINLP**	MINLP	MINLP	MINLP
Obj	**213.15**	212.97	182.21	182.21
PQ_{11}	8.46	8.43	0.07	0.07
PQ_{21}	7.96	7.87	0.08	0.08
PQ_{12}	7.35	7.31	0.10	0.10
PQ_{22}	6.78	6.75	0.11	0.11
x_{11}	10	10	10	10
x_{21}	0	0	0	0
x_{12}	10	10	10	10
x_{22}	0	0	0	0
a_{11}	0.15	0.15	0.05	0.05
a_{21}	0.14	0.14	0.06	0.06
a_{12}	0.13	0.13	0.07	0.07
a_{22}	0.12	0.12	0.08	0.08
I_1	1	1	1	1
I_2	0.50	0.50	0.50	0,50
B	1.07	1.07	0.93	0.93
T_l	1000	1000	1000	1000
Lx	2.37	2.37	2.37	2.37
x	1	1	0	0

B. Case 2: α as parameter and β as variable

Case a: PQ_{ij} increases and x increases

Max $R = (0.5 + PQ_{11}) + ((0.1+\beta_1 I_1)15x_{11}) + (0.6 + PQ_{21}) + ((0.1+\beta_2 I_2)15x_{21}) + (0.7 + PQ_{11}) + ((0.1+\beta_1 I_1)15x_{12}) + (0.8 + PQ_{22}) + ((0.1+\beta_2 I_2)15x_{22})$ (3)

Subject to

$\beta_2 0.01 \geq \beta_1 0.01$ (3a)

$0.01 \leq \beta_1 \leq 0.5$

$0.01 \leq \beta_2 \leq 0.5$ (3b)

and Eq.(1a)-(1m)

For case b when PQ_{ij} increases and x decreases then, the objective function (3) will be maximized with subject to Eq.(2a), Eq.(1a)-(1e), Eq. (1g)-(1m) and Eq.(3a)-(3b). Then, for case c when PQ_{ij} decreases and x increases, the objective function will be Eq. (3) subject to (1a)-(3b). Case d will maximize the Eq.(3) subject to Eq.(2a), Eq.(1a)-(1e) and Eq. (1g)-(3b).

Table V shows the highest value is achieved when the case of PQ_{ij} increases and x increases and for case of PQ_{ij} increases and x decrease so ISP can adopt the IRC scheme.

TABLE V. OPTIMAL SOLUTION OFIMPROVED IRC OF DIGILIB TRAFFIC WHEN $\boldsymbol{\alpha}$ AS PARAMETER AND $\boldsymbol{\beta}$ AS VARIABLE

Var	PQ_{ij} and x increase	PQ_{ij} increases x decreases	PQ_{ij} decreases x increases	PQ_{ij} and x decrease
Model Class	**MINLP**	MINLP	MINLP	MINLP
Objective	**64.65**	**64.65**	33.72	33.72
PQ_{11}	8.46	8.43	0.07	0.07
PQ_{21}	7.92	7.87	0.08	0.08
PQ_{12}	7.35	7.31	0.10	0.10
PQ_{22}	6.78	6.75	0.11	0.11
x_{11}	10	10	10	10
x_{21}	0	0	0	0
x_{12}	10	10	10	10
x_{22}	0	0	0	0
a_{11}	0.15	0.15	0.05	0.05
a_{21}	0.14	0.14	0.06	0.06
a_{12}	0.13	0.13	0.07	0.07
a_{22}	0.12	0.12	0.08	0.08
I_1	0.01	0,01	0.01	0.01
I_2	0.01	0.01	0.01	0.01
B	1.07	1.07	0.93	0.93
T_l	1000	1000	1000	1000
Lx	2.37	2.37	2.37	2.37
x	1	1	0	0

C. Case 3: α and β as variable

Case a: PQ_{ij} and x increase

Max R = (0.5+ PQ_{11})+((α_1+$\beta_1 I_1$)15x_{11}) +(0.6+ PQ_{21})+((α_2+$\beta_2 I_2$)15x_{21})+(0.7+PQ_{11})+((α_1+$\beta_1 I_1$)15x_{12})+(0.8+PQ_{22})+((α_2+$\beta_2 I_2$)15x_{22}) (4)

Subject to

$\alpha_2 + \beta_2 I_2 \geq \alpha_1 + \beta_1 I_1$ (4a)

$0 \leq \alpha_1 \leq 1$

$0 \leq \alpha_2 \leq 1$ (4b)

Eq. (1a)-(1m), Eq.(3a)-(3b)

For Case b: PQ_{ij} increases and x decreases, Eq.(4) will be maximized subject to Eq.(2a), Eq. (1a)-(1e), Eq. (1g)-(3b) and Eq. (4a)-(4b). For case c: PQ_{ij} decreases and x increases, objective function (4) will be maximized subject to Eq. (1a)-(4b) and for case d: PQ_{ij} and x decrease, objective function (4) will be maximized subject to Eq.(2a), Eq. (1a)-(1e) and (1g)-(4b).

As Table VI described, the solution again is achieved when PQ_{ij} and x increase. All cases show model as mixed integer nonlinear programming (MINLP) problem.

TABLE VI. OPTIMAL SOLUTION OF IMPROVED IRC FOR DIGILIB TRAFFIC WHEN α AND β AS VARIABLES

Var	PQ_{ij} and x increase	PQ_{ij} increases x decreases	PQ_{ij} decreases x increases	PQ_{ij} and x decrease
Model Class	**MINLP**	MINLP	MINLP	MINLP
Obj	**334.65**	334.48	303.72	303.72
PQ_{11}	8.46	8.43	0.07	0.07
PQ_{21}	7.92	7.87	0.08	0.08
PQ_{12}	7.35	7.31	0.1	0.1
PQ_{22}	6.78	6.75	0.11	0.11
x_{11}	10	10	10	10
x_{21}	0	0	0	0
x_{12}	10	10	10	10
x_{22}	0	0	0	0
a_{11}	0.15	0.15	0.05	0.05
a_{21}	0.14	0.14	0.06	0.06
a_{12}	0.13	0.13	0.07	0.07
a_{22}	0.12	0.12	0.08	0.08
I_1	0.01	0.01	0.01	0.01
I_2	0.01	0.01	0.01	0.01
B	1.07	1.07	0.93	0.93
T_l	1000	1000	1000	1000
Lx	2.37	2.37	2.37	2.37
x	1	1	0	0

Case 4: α as variable and β as parameter

Case a: PQ_{ik} and x increase

Max R = (0.5+ PQ_{11})+((α_1+0.5I_1)15x_{11}) +(0.6+ PQ_{21})+((α_2+0.5I_2)15x_{21}) +(0.7+ PQ_{11})+((α_1+0.5I_1)15x_{12}) +(0.8+ PQ_{22})+((α_2+0.5I_2)15x_{22}) (5)

Subject to

a_2+$I_2 \geq a_1$+I_1 (5a)

Eq.(1a)-(1m) and Eq.(4b).

Case b for PQ_{ik} increases and x decreases will maximize objective function (5) subject to Eq.(2a),Eq.(1a)-(1e), Eq.(1g)-(1m), Eq.(4b) and Eq.(5a). Case c for PQ_{ik} decreases and x increases will maximize the objective function (5) subject to Eq.(1a)-(1m), Eq.(3b), Eq.(5a). Last case, for PQ_{ik} and x decrease, the objective function (5) will be maximized subject to Eq.(5a), Eq. (1a)-(1e), Eq. (1g)-(1m), Eq.(3b) and Eq.(4a)

TABLE VII. OPTIMAL SOLUTION OF IRC FOR DIGILIB TRAFFIC WHEN α VARIABLE AND β AS PARAMETER

Var	PQ_{ij} and x increase	PQ_{ij} increases x decreases	PQ_{ij} decreases x increases	PQ_{ij} and x decrease
Model Class	**MINLP**	MINLP	MINLP	MINLP
Obj	**334.65**	334.48	303.72	303.72
PQ_{11}	8.46	8.43	0.07	0.07
PQ_{21}	7.92	7.87	0.08	0.08
PQ_{12}	7.35	7.31	0.1	0.1
PQ_{22}	6.78	6.75	0.11	0.11
x_{11}	10	10	10	10
x_{21}	0	0	0	0
x_{12}	10	10	10	10
x_{22}	0	0	0	0
a_{11}	0.15	0.15	0.05	0.05
a_{21}	0.14	0.14	0.06	0.06
a_{12}	0.13	0.13	0.07	0.07
a_{22}	0.12	0.12	0.08	0.08
I_1	0.01	0.01	0.01	0.01
I_2	0.01	0.01	0.01	0.01
B	1.07	1.07	0.93	0.93
T_l	1000	1000	1000	1000
Lx	2.37	2.37	2.37	2.37
x	1	1	0	0

Table VII depicted the optimal solution for last case. It occur the same case when PQ_{ij} and x increase. From Table III-IV it can be examined that only for case 2 when α as parameter and β as variable then the objective function of two models show the same results. It means that when ISP set up the base price for the pricing scheme that will be adopted, then ISP can choose the scheme with when α as parameter and β as variable with the requirement of PQ_{ij} increases and x increases and PQ_{ij} increases and x decreases.

Compared to results proposed by Puspita et al [1], our new improved results show better performance in terms of generalization of links to include more realistic network. In fact, this result can be a suggestion to ISP for generating parameter and variables necessary to their network to gain more revenue.

IV. CONCLUDING REMARKS

The schemes proposed can be used as preferences for Internet Service Provider (ISP) to be adopted in multiple link Quality of Service network if end-to-end delay QoS attribute is applied. The choice of setting the base price varies and the quality premium varies or to be fixed can be proven to be powerful of ISP to get highest profit. ISP will get market competition by varying the base price and the choice to vary or fix the quality premium will promote certain services or enable customer to select the class in services, respectively.

For further research, it is better to see other QoS attributes that can be applied for the network and seek for comparison to seek best scheme among attributes and to also seek for advantages and disadvantages mathematically for applying the schemes with other attributes.

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