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13

				IEEE Xplar	re - Conference Ta	ble of Contents			
IEEE.org IEE	EE Xplore	IEEE-SA	IEEE Spectrum	More Sites	SUBSCRIBE	SUBSCRIBE	Cart	Create Account	
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5	0 of 118							🗟 Email	
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T Filter Refine Author Affiliation	• •	Ma Ci An Pu	etering Infrastruct ties rizky Ayu Faradila P iblication Year: 2019 Abstract Designing LoRa Advanced Meter	I Internet of Th ure (AMI) in Su urnama ; Muhar), Page(s): 194 - (2763 WAN Interne ring Infrastrue	nings Network for rabaya and its Su mmad Imam Nash 199 Kb) t of Things Net	Advanced irrounding iruddin work for		ı 🛎 Email	
Filter Refine Author Affiliation Conference) of 118 ~ ~ ~	An Pu	etering Infrastruct ties izky Ayu Faradla P Abitration Year: 2019 Abstract Designing LoRa Advanced Meter and Its Surround	I Internet of Th ure (AMI) in Su urnama ; Muhar), Page(s): 194 - (2783 WAN Interne ring Infrastruc ding Cities	nings Network for rrabaya and its So mmad Imam Nash 199 Ka) et of Things Net cture (AMI) in S	r Advanced arrounding iruddin work for Gurabaya		ı 🖀 Email	
T Filter Refine Author Affiliation) of 118 ~ ~ ~	An Pu	etering Infrastruct ties rizky Ayu Faradila P iblication Year: 2019 Abstract Designing LoRa Advanced Meter	I Internet of Th ure (AMI) in Su urnama ; Muhar (2763 WAN Interne ring Infrastru ding Cities 1 Purnama ; Muh	hings Network for irrabaya and its St mmad imam Nash • 199 Kb) tt of Things Net cture (AMI) in S hammad imam Na	r Advanced irrounding iruddin twork for turabaya shiruddin		ı 🖀 Email	
Filter Refine Author Affiliation Conference	• • •	Mi Ci An Pu	etering Infrastruct ties rizky Ayu Faradila P bilication Year: 2019 Abstract Designing LoRa Advanced Meter and Its Surroux Arrizky Ayu Faradila 2019 International S and Intelligent Syste	I Internet of Th ure (AMI) in Su urnama ; Muhar ; Page(s): 194 - (2783 WWAN Interne ring Infrastruc ding Cities a Purnama ; Mut ieminar on Rese	hings Network for irrabaya and its St mmad imam Nash • 199 Kb) tt of Things Net cture (AMI) in S hammad imam Na	r Advanced irrounding iruddin twork for turabaya shiruddin		ı 🕿 Email	
Filter Refine Author Affiliation Conference Location Quick Links Search for Upcomi	* *	Mi Ci An Pu	etering Infrastruct ties rizky Ayu Faradia P bilication Year: 2019 Abstract Designing LoRa Advanced Meter and Its Surround Arrizky Ayu Faradila 2019 International S	I Internet of Th ure (AMI) in Su urnama ; Muhar ; Page(s): 194 - (2783 WWAN Interne ring Infrastruc ding Cities a Purnama ; Mut ieminar on Rese	hings Network for irrabaya and its St mmad imam Nash • 199 Kb) tt of Things Net cture (AMI) in S hammad imam Na	r Advanced irrounding iruddin twork for turabaya shiruddin		ı 🕿 Email	
Filter Refine Author Affiliation Conference Location Quick Links Search for Upcomi Conferences	* *	Mi Ci An Pu	etering Infrastruct ties irizky Ayu Faradila P bilication Year: 2019 Abstract Designing LoRa Advanced Meter and Its Surroux Arrizky Ayu Faradila 2019 International S and Intelligent Syste Year: 2019	I Internet of Th ure (AMI) in Su urnama ; Muhar 2783 WAN Interne ring Infrastruc ding Cities a Purnama ; Muh eeminar on Reso ems (ISRITI)	nings Network for rrabaya and its Su mmad Imam Nash 199 isa) et of Things Net cture (AMI) in S hammad Imam Na sarch of Informatio	Advanced irrounding iruddin twork for iurabaya shiruddin n Technology		ı 🕿 Email	
Filter Refine Author Affiliation Conference Location Quick Links Search for Upcomit Conferences EEE Publication Recommender	v v ing	Mi Ci An Pu	etering Infrastruct ties rizky Ayu Faradia P bilication Year: 2019 Abstract Designing LoRa Advanced Meter and Its Surround Arrizky Ayu Faradia 2019 International S and Intelligent Syste Year: 2019 esign of Automated rensy Donabela ; M	I Internet of Th urre (AMI) in Su urnama ; Muhar (2783 WAN Interne ring Infrastruc ding Cities Purnama ; Muh eminar on Res ams (ISRITI) d Polarization I L Azza Ulin Nuh	hings Network for irrabaya and its So mmad Imam Nash 199 sto isto tof Things Net cture (AMI) in S hammad Imam Na earch of Informatio based on EDU-Q(ia ; Rini Wisnu Wa	r Advanced irrounding iruddin work for Gurabaya shiruddin n Technology CRY 1 rdhani ;		ı 🕊 Emai	
Filter Refine Author Affiliation Conference Location Quick Links Search for Upcomit Conferences IEEE Publication	v v ing	Mic Ci Pu Ci Ci Ci Ci Ci Ci Ci Ci Ci Ci Ci Ci Ci	etering Infrastruct ties izky Ayu Faradila P Iblication Year: 2019 Abstract Designing LoRa Advanced Meteria and Its Surround Arricky Ayu Faradila 2019 International S and Intelligent Syste Year: 2019	I Internet of Th ure (AMII) in Su urnama ; Muhar (2783 WAN Interne ring Infrastru ding Cities Purnama ; Muh eminar on Reso mms (ISRITI) d Polarization I L Azza Ulin Nuh on Ogi ; Dedy S	hings Network for irabaya and its St mmad imam Nash • 199 Kb) tt of Things Net cture (AMI) in S hammad imam Na earch of Informatio based on EDU-Q(as ; Rini Wisnu Wa Septono Catur Putr	r Advanced irrounding iruddin work for Gurabaya shiruddin n Technology CRY 1 rdhani ;		ı 🕊 Emai	
Filter Filter Refine Author Affiliation Conference Location Quick Links Search for Upcomi Conferences EEE Publication Recommender EEE Author Certe Proceedings	v v ing	Mic Ci Pu Ci Ci Ci Ci Ci Ci Ci Ci Ci Ci Ci Ci Ci	etering Infrastruct ties rizky Ayu Faradia P bilication Year: 2019 Abstract Designing LoRa Advanced Meter and Its Surround Arrizky Ayu Faradia 2019 International S and Intelligent Syste Year: 2019 esign of Automated rensy Donabela ; M	I Internet of Th ure (AMII) in Su urnama ; Muhar (2783 WAN Interne ring Infrastru ding Cities Purnama ; Muh eminar on Reso mms (ISRITI) d Polarization I L Azza Ulin Nuh on Ogi ; Dedy S	hings Network for irrabaya and its Su mmad imam Nash 199 isb) et of Things Net cture (AMI) in S hammad imam Na earch of Informatio based on EDU-Q(ia ; Rini Wisnu Wa septono Catur Putr + 443	r Advanced irrounding iruddin work for Gurabaya shiruddin n Technology CRY 1 rdhani ;		ı 🕊 Emai	
Filter Refine Author Affiliation Conference Location Quick Links Search for Upcomit Conferences EEE Publication Recommender EEE Author Cente Proceedings The proceedings of	ing r fthis	Mi Ci Pu Ci Ci Ci Ni Pu	etering Infrastruct ties izky Ayu Faradila P bilication Year: 2019 Abstract Designing LoRa Advanced Meter and Its Surround Arrizky Ayu Faradila 2019 International S and Intelligent Syste Year: 2019 esign of Automated rrensy Donabela ; M shamad Syahral ; Di bilication Year: 2019 Design of Autom	I Internet of Th ure (AMI) in Su umama ; Muhar ; Page(s): 194-4 (2283 WAN Interne ring Infrastruc ding Cities a Purnama ; Mut eeminar on Rese erms (ISRITI) d Polarization I L Azza Jlin Nuh on Ogi ; Dedy S , Page(s): 439- (297 k	hings Network for rrabaya and its St mmad Imam Nash 199 (ta) to of Things Net cture (AMI) in S hammad Imam Na earch of Informatio based on EDU-Q(a ; Rini Wisnu Wa Septono Catur Putr 443 (b)	Advanced irrounding iruddin twork for curabaya shiruddin n Technology CRY 1 rdhani ; anto		ı 📽 Emai	
Filter Filter Refine Author Affiliation Conference Location Quick Links Search for Upcomi Conferences EEE Publication Recommender EEE Author Certe Proceedings	ing r fthis available	Mi Ci An Pu Ci Ci Ci Ni Pu	etering Infrastruct ties izky Ayu Faradila P bilication Year: 2019 Abstract Designing LoRa Advanced Meter and Its Surround Arrizky Ayu Faradila 2019 International S and Intelligent Syste Year: 2019 esign of Automated rrensy Donabela; N shamad Syahral; Di bilication Year: 2019 Abstract Design of Autom QCRY 1	I Internet of Th urre (AMII) in Su urnama ; Muhar (2783 WAN Interne ring Infrastruc ding Cities Purnama ; Muh eeminar on Reso ems (ISRITI) d Polarization II L Azza Ulin Nuh ion Ogi ; Dedy S A, Page(s): 439 - (297 # nated Polariza	hings Network for irrabaya and its Su mmad Imam Nash 199 et of Things Net cture (AMI) in S hammad Imam Na earch of Informatio based on EDU-Q(is; Rini Wisnu Wa Septono Catur Putr 443 (b) ation based on	r Advanced arrounding iuddin twork for burabaya shiruddin n Technology CRY 1 rdhani ; anto		ı 🗲 Emai	
Filter Refine Author Affiliation Conference Location Quick Links Search for Upcomit Conferences IEEE Publication Recommender IEEE Author Cente Proceedings The proceedings of conference will be a	v v ing r f this available gh	Mi Ci Pu Ci Ci Ci Mi Pu	etering Infrastruct ties izky Ayu Faradila P Abstract Designing LoRa Advanced Meta and Its Surround Arricky Ayu Faradila 2019 International S and Intelligent Syste Year: 2019 esign of Automated rensy Donabela ; M shamad Syahral ; Di blication Year: 2019 Abstract Design of Autom QCRY 1 Carensy Donabela ;	I Internet of Th ure (AMII) in Su urnama ; Muhar (2783 WAN Interne ring Infrastrux ding Cities Purnama ; Muh eminar on Res ams (ISRITI) d Polarization I L Azza Ulin Nuh ion Ogi ; Dedy S (297 k nated Polariz ; M Azza Ulin N	hings Network for rrabaya and its Su mmad imam Nash - 199 (%) (%) (%) to f Things Net cture (AMI) in S hammad imam Na earch of Informatio based on EDU-Q(ia ; Rini Wisnu Wa Septono Catur Putr - 443 (%) ation based on luha ; Rini Wisnu V	r Advanced rrounding iuddin twork for turabaya shiruddin n Technology CRY 1 rdhani ; anto EDU- Vardhani ;		ı 📽 Emai	
Filter Refine Author Affiliation Conference Location Quick Links Search for Upcomit Conferences IEEE Publication Recommender IEEE Author Cente Proceedings The proceedings of conference will be a for purchase througe	r fthis available gh	Mi Ci Pu Ci Ci Ci Ci Ci Mi Pu	etering Infrastruct ties izky Ayu Faradila P bilication Year: 2019 Abstract Designing LoRa Advanced Meter and Its Surround Arrizky Ayu Faradila 2019 International S and Intelligent Syste Year: 2019 esign of Automated rrensy Donabela; N shamad Syahral; Di bilication Year: 2019 Abstract Design of Autom QCRY 1	I Internet of Th ure (AMI) in Su urnama ; Muhar (2783 WAN Interne ring Infrastru ding Cities a Purnama ; Muh eminar on Rese eminar on Rese eminar on Rese eminar on Rese eminar on Rese ams (ISRITI) d Polarization II (Azza Ulin Nuh ion Ogi ; Dedy S a, Page(s): 439 - (297 + nated Polarizi	hings Network for irrabaya and its St mmad Imam Nash • 199 80) et of Things Net cture (AMI) in S hammad Imam Na sarch of Informatio based on EDU-Q(ba ; Rini Wismu Wa Septono Catur Putr • 443 th) ation based on utha ; Rini Wismu V y Septono Catur P	Advanced arrounding iruddin twork for iurabaya shiruddin n Technology CRY 1 rdhani ; anto EDU- Vardhani ; utranto		ı 🖉 Emai	
Filter Refine Author Affiliation Conference Location Quick Links Saarch for Upcomit Conferences EEE Publication Recommender EEE Author Cente Proceedings The proceedings of conference will bea for purchase throug Curran Associates. Research of Infor Technology and	ing r f this available gh mation	Mi Ci An Pu Ci Ci Mi Pu	etering Infrastruct ties irizky Ayu Faradila P bilication Year: 2019 Abstract Designing LoRa Advanced Meter and Its Surroux Arrizky Ayu Faradila 2019 International S and Intelligent Syste Year: 2019 esign of Automater arrensy Donabela ; M hamad Syahral ; Di bilication Year: 2019 Abstract Design of Autom QCRY 1 Carensy Donabela ; Mohamad Syahral ; 2019 International S and Intelligent Syste	I Internet of Th ure (AMII) in Su urnama ; Muhar ; Page(s): 194- (2783 WAN Interne ring Infrastruc ding Cities a Purnama ; Mul eaminar on Reso mms (ISRITI) d Polarization I L Azza Ulin Nuh con Ogi ; Dedy S , Page(s): 439- (277 hated Polariz ; M Azza Ulin N Dion Ogi ; Dedy ceminar on Reso	hings Network for irrabaya and its St mmad Imam Nash • 199 80) et of Things Net cture (AMI) in S hammad Imam Na sarch of Informatio based on EDU-Q(ba ; Rini Wismu Wa Septono Catur Putr • 443 th) ation based on utha ; Rini Wismu V y Septono Catur P	Advanced arrounding iruddin twork for iurabaya shiruddin n Technology CRY 1 rdhani ; anto EDU- Vardhani ; utranto		ı 🖉 Emai	
Filter Refine Author Affiliation Conference Location Quick Links Search for Upcomi Conferences EEE Publication Recommender EEE Author Cente Proceedings The proceedings of conference will be a for purchase throug Curran Associates. Research of Infon Technology and Intelligent System	ing r f this available gh mation	Mi Ci An Pu Ci Ci Mi Pu	etering Infrastruct ties itzky Ayu Faradila P bilication Year: 2019 Abstract Designing LoRa Advanced Meter and Its Surroux Arrizky Ayu Faradila 2019 International S and Intelligent Syste Year: 2019 esign of Automated Amand Syahral ; Di bilication Year: 2019 Abstract Design of Autom QCRY 1 Carensy Donabela ; M hohamad Syahral ; 2019 International S	I Internet of Th ure (AMII) in Su urnama ; Muhar ; Page(s): 194- (2783 WAN Interne ring Infrastruc ding Cities a Purnama ; Mul eaminar on Reso mms (ISRITI) d Polarization I L Azza Ulin Nuh con Ogi ; Dedy S , Page(s): 439- (277 hated Polariz ; M Azza Ulin N Dion Ogi ; Dedy ceminar on Reso	hings Network for irrabaya and its St mmad Imam Nash • 199 80) et of Things Net cture (AMI) in S hammad Imam Na sarch of Informatio based on EDU-Q(ba ; Rini Wismu Wa Septono Catur Putr • 443 th) ation based on utha ; Rini Wismu V y Septono Catur P	Advanced arrounding iruddin twork for iurabaya shiruddin n Technology CRY 1 rdhani ; anto EDU- Vardhani ; utranto		I	
Filter Refine Author Affiliation Conference Location Quick Links Saarch for Upcomit Conferences EEE Publication Recommender EEE Author Cente Proceedings The proceedings of conference will bea for purchase throug Curran Associates. Research of Infor Technology and	r fthis available gh mation ns	Mi An Pu Ci Ci Mi Pu	stering Infrastruct tites izky Ayu Faradila P bilication Year: 2019 Abstract Designing LoRa Advanced Meter and Its Surround Arrizky Ayu Faradila 2019 International S and Intelligent Syste Year: 2019 esign of Automated rensy Donabela ; M shamad Syahral ; Di bilication Year: 2019 Abstract Design of Autom QCRY 1 Carensy Donabela ; Mohamad Syahral ; 2019 International S and Intelligent Syste Year: 2019	I Internet of Th ure (AMII) in Su umama ; Muhar ; Page(s): 194-4 (2783 WAN Interne ring Infrastru- ding Cities i Purnama ; Muh eeminar on Rese emis (ISRITI) d Polarization II t. Azza Ulin Nuh ion Ogi ; Dedy S , Page(s): 439- (207 k nated Polarization II Dion Ogi ; Dedy S ; M. Azza Ulin Nuh ieminar on Rese eminar on Rese eminar on Rese	hings Network for irrabaya and its Su mmad Imam Nash 199 ito f Things Net cture (AMI) in S hammad Imam Na earch of Informatio based on EDU-Q(ia ; Rini Wisnu Wa Septono Catur Putr 443 (b) ation based on uha ; Rini Wisnu V y Septono Catur P esarch of Informatio	r Advanced irrounding iruddin twork for burabaya shiruddin n Technology CRY 1 rdhani ; anto EDU- Vardhani ; utranto n Technology		I	
Filter Refine Author Affiliation Conference Location Quick Links Search for Upcomi Conferences IEEE Publication Recommender IEEE Author Cente Proceedings The proceedings of conference will be a for purchase throug Curran Associates. Research of Infor Technology and Intelligent System (ISRITI), 2019	r fthis available gh mation ns inar on	Mi Ci Pu Ci Ci Ci Mi Pu Ci	etering Infrastruct ties irizky Ayu Faradila P bilication Year: 2019 Abstract Designing LoRa Advanced Meter and Its Surroux Arrizky Ayu Faradila 2019 International S and Intelligent Syste Year: 2019 esign of Automater arrensy Donabela ; M hamad Syahral ; Di bilication Year: 2019 Abstract Design of Autom QCRY 1 Carensy Donabela ; Mohamad Syahral ; 2019 International S and Intelligent Syste	I Internet of Th ure (AMI) in Su urnama ; Muhar (2783 WAN Interne ring Infrastru ding Cities Purnama ; Muh eminar on Ress ams (ISRITI) d Polarization It (Azza Ulin Nuh ion Ogi ; Dedy S Page(s): 439- (277 k nated Polariz ; M. Azza Ulin N Dion Ogi ; Dedy eminar on Ress ams (ISRITI)	hings Network for irrabaya and its Si mmad Imam Nash • 199 it of Things Net cture (AMI) in S hammad Imam Na earch of Informatio based on EDU-Q(a ; Rini Wisnu Wa Septono Catur Putr • 443 ta) ation based on luha ; Rini Wisnu V y Septono Catur P sarch of Informatio	Advanced arrounding iruddin twork for jurabaya shiruddin n Technology CRY 1 rdhani ; anto EDU- Vardhani ; utranto n Technology		I	

https:///eeexplore.ieee.org/xpl/conhome/9027964/proceeding?pageNumber=4

	ILLE April 6 - Gallerence have of Gallere
0	Indonesia Toll Road Vehicle Classification Using Transfer Learning with Pre-trained Resnet Models
	Ananto Tri Sasongko ; Mohamad Ivan Fanany Publication Year: 2019, Page(s): 373 - 378 Abstract (586 Kb)
0	Indonesia Toll Road Vehicle Classification Using Transfer Learning with Pre-trained Resnet Models
	Ananto Tri Sasongko; Mohamad Ivan Fanany 2019 International Seminar on Research of Information Technology and Intelligent Systems (ISRITI) Year: 2019
0	ZSI Application for Reducing the Energy Incident of Arc Flash in a Distribution System Finis Fliana ; Mfla Nur Farid ; Muhammad Abdillah
	Publication Year: 2019, Page(s): 379 - 383 Abstract (251 Kb)
0	ZSI Application for Reducing the Energy Incident of Arc Flash in a Distribution System
	Firilia Filiana ; Mifta Nur Farid ; Muhammad Abdillah
	2019 International Seminar on Research of Information Technology and Intelligent Systems (ISRITI) Year: 2019
	Improved internet wireless reverse charging models under multi link service network by end-to-end delay QoS attribute
	Fibri Maya Puspita ; Weny Herlina ; Septia Anggraini ; Bella Arisha ;
	Yunita Yunita Publication Year: 2019, Page(s): 182 • 187
_	Abstract (298 Kb)
	Improved internet wireless reverse charging models under multi link service network by end-to-end delay QoS attribute
	Fitri Maya Puspita ; Weny Herlina ; Septia Anggraini ; Bella Arisha ; Yunita Yunita
	2019 International Seminar on Research of Information Technology and Intelligent Systems (ISRITI) Year: 2019
	Design and Simulation of Side Rail Strength and Latch Reliability for Medical Beds Testing Using FluidSim
	Sutrisno Salomo Hutagalung ; Imamul Muchlis ; Khusnul Khotimah ;
	Siddiq Wahyu Hidayat Publication Year: 2019, Page(s): 483 • 487
_	Abstract (899 Kb)
0	Reliability for Medical Beds Testing Using FluidSim
	Sutrisno Salomo Hutagalung ; Imamul Muchlis ; Khusnul Khotimah ; Siddiq Wahyu Hidayat
	2019 International Seminar on Research of Information Technology
	and Intelligent Systems (ISRITI) Year: 2019
0	Dropout Prediction Optimization through SMOTE and Ensemble Learning
	Eko Mulyani ; Indriana Hidayah ; Silmi Fauziati
	Publication Year: 2019, Page(s): 516 - 521 Abstract (977 Kb)
	Dropout Prediction Optimization through SMOTE and
	Ensemble Learning
0	

https://ieeexplore.ieee.org/xpl/conhome/9027964/proceeding?pageNumber=4

7/1/2020

IEEE Xplore - Conference Table of Contents

	Monitoring System in Lora Network Architecture using Smart Gateway in Simple LoRa Protocol
	Dania Eridani ; Eko Didik Widianto ; Richard Dwi Olympus Augustinus ;
	Al Arthur Faizal
	Publication Year: 2019, Page(s): 200 • 204
	Abstract (500 Kb)
	Monitoring System in Lora Network Architecture using Smart Gateway in Simple LoRa Protocol
	Dania Eridani ; Eko Didik Widianto ; Richard Dwi Olympus Augustinus ; Al Arthur Faizal
	2019 International Seminar on Research of Information Technology and Intelligent Systems (ISRITI)
	Year: 2019
2	Collaborative Whitelist Packet Filtering Driven by Smart Contract Forum
	Fahrudin Mukti Wibowo ; Muhammad Fajar Sidiq ; Imadudin Alif Akbar ; Akbari Indra Basuki ; Didi Rosiyadi
	Publication Year: 2019, Page(s): 205 • 210
	Abstract (898 Kb)
	Collaborative Whitelist Packet Filtering Driven by Smart
	Contract Forum
	Fahrudin Mukti Wibowo ; Muhammad Fajar Sidiq ; Imadudin Alif
	Akbar ; Akbari Indra Basuki ; Didi Rosiyadi
	2019 International Seminar on Research of Information Technology
	2019 International Seminar on Research of Information Technology and Intelligent Systems (ISRITI)

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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-toend 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.

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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 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
С	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>i</i> at the link <i>j</i>
m _i	Minimum QoS for service i
n_i	The number of users of the service <i>i</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 <i>Tl</i>
k	Limitation of traffic load that is allowed to Tl
<i>g</i> _i	Limit values specified for the service provider a_{ii}

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>i</i> at link <i>j</i>
PB_{ij}	The basic fee for a connection with the service <i>i</i> and <i>j</i> link
a _{ij}	Linear cost factor in the service <i>i</i> and link <i>j</i>
I_i	The base price of the minimum required for service <i>i</i>
Τl	Traffic load
Lx	Linearity factor
x	Some of the increase or decrease in the value of QoS
В	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).

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 $l(n_1)$	10
Number of users of the service $2(n_2)$	10

TABLE III. VALUES OF QOS PARAMETERS IN IRC MODELS

A. Case 1: α and β Constants

The four subcases are explained as follows. Case a : PQ_{ij} increases and x increases

 $\begin{aligned} \text{Max } R &= (0.5 + PQ_{11}) + ((0.1 + 0.5I_1)15x_{11}) + (0.6 + PQ_{21}) + \\ ((0.1 + 0.5I_2) + 15x_{21}) + (0.7 + PQ_{12} + ((0.1 + 0.5I_1)15x_{12}) + (0.8 + PQ_{22}) + ((0.1 + 0.5I_2)15x_{22}) \end{aligned} \tag{1}$ Subject to $I_1 d_{11} x_{11} \leq a_1 C_1 \\ I_2 d_{21} x_{21} \leq a_2 C_1 \\ I_1 d_{12} x_{12} \leq a_1 C_2 \end{aligned}$

$$I_{2}d_{22}x_{22} \le a_{2}C_{2}$$
(1a)
(I_{1}d_{11}x_{11}) + (I_{2}d_{21}x_{21}) \le (a_{1}+a_{2})C_{1}

$$(I_1d_{12}x_{12})+(I_2d_{22}x_{22}) \le (a_1+a_2)C_2$$
 (1b)

$$a_1+a_2=1$$
 (1c)
 $0.01 < I_1 < 1$

$$\begin{array}{l} 0.01 \le I_2 \le 1 \\ 0 \le x_{11} \le 10 \end{array} \tag{1d}$$

$$\begin{array}{l}
0 \le x_{21} \le 10 \\
0 \le x_{12} \le 10 \\
0 \le x_{22} \le 10
\end{array} (1e)$$

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

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

$$PQ_{12} = \left(1 + \frac{x}{250}\right) PB_{12}Lx$$

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

$$PB_{11} = a_{11}(e \cdot e^{-xB}) \frac{T_{l}}{T_{l}}$$
(1f)

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

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

$$PB_{22} = a_{12}(e - e^{-xB}) \frac{T_l}{100}$$

$$PB_{22} = a_{12}(e - e^{-xB}) \frac{T_l}{100}$$

$$PB_{22} = a_{12}(e - e^{-xB}) \frac{T_l}{100}$$

$$PB_{23} = a_{13}(e - e^{-xB}) \frac{T_l}{100}$$

$$PB_{23} = a_{23}(e - e^{-xB}) \frac{T_l}{100}$$

$$PB_{22} = a_{11}(e - e^{-xB})$$
(1g)
$$Lx = a(e - e^{-xB})$$
(1h)

$$\begin{array}{c} 0.05 \leq a_{11} \leq 0.15 \\ 0.06 \leq a_{21} \leq 0.14 \\ 0.07 \leq a_{12} \leq 0.13 \\ 0.08 \leq a_{22} \leq 0.12 \\ 50 \leq T_l \leq 1000 \\ 0 \leq x \leq 1 \\ 0.8 \leq B \leq 1.07 \\ a = 1 \end{array}$$
(1i)

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 α dan 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	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
<i>x</i> ₁₁	10	10	10	10
<i>x</i> ₂₁	0	0	0	0
<i>x</i> ₁₂	10	10	10	10
<i>x</i> ₂₂	0	0	0	0
<i>a</i> ₁₁	0.15	0.15	0.05	0.05
<i>a</i> ₂₁	0.14	0.14	0.06	0.06
<i>a</i> 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
В	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

 $\begin{array}{ll} \text{Max } R &= (0.5 + PQ_{11}) + ((0.1 + \beta_1 I_1) 15 x_{11}) + (0.6 + PQ_{21}) + \\ ((0.1 + \beta_2 I_2) 15 x_{21}) + (0.7 + PQ_{11}) + ((0.1 + \beta_1 I_1) 15 x_{12}) + (0.8 + \\ PQ_{22}) + ((0.1 + \beta_2 I_2) 15 x_{22}) & (3) \\ \text{Subject to} & \\ \beta_2 0.01 \geq \beta_1 0.01 & (3a) \\ 0.01 \leq \beta_1 \leq 0.5 & (3b) \\ \text{and Eq.(1a)-(1m)} & \end{array}$

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.

N7	PQ _{ij} and	PQ _{ij} increases	PQ _{ij} decreases	PQ _{ij} and
Var	x	x	x	x
	increase	decreases	increases	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
PQ22	6.78	6.75	0.11	0.11
<i>x</i> ₁₁	10	10	10	10
<i>x</i> ₂₁	0	0	0	0
<i>x</i> ₁₂	10	10	10	10
<i>x</i> ₂₂	0	0	0	0
a ₁₁	0.15	0.15	0.05	0.05
<i>a</i> ₂₁	0.14	0.14	0.06	0.06
<i>a</i> 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
В	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 V. Optimal Solution of Improved IRC of Digilib Traffic when α as Parameter and β as Variable

C. Case 3: α and β as variable

Case a: PQ_{ii} and x increase

 $\text{Max} \quad R = (0.5+ PQ_{11}) + ((\alpha_1 + \beta_1 I_1) 15x_{11}) + (0.6+ PQ_{21}) + ((\alpha_2 + \beta_2 I_2) 15x_{21}) + (0.7 + PQ_{11}) + ((\alpha_1 + \beta_1 I_1) 15x_{12}) + (0.8 + PQ_{22}) + ((\alpha_2 + \beta_2 I_2) 15x_{22})$ (4)

Subject to	
$\alpha_2 + \beta_2 I_2 \ge \alpha_1 + \beta_1 I_1$	(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
<i>x</i> ₁₁	10	10	10	10
<i>x</i> ₂₁	0	0	0	0
<i>x</i> ₁₂	10	10	10	10
<i>x</i> ₂₂	0	0	0	0
<i>a</i> ₁₁	0.15	0.15	0.05	0.05
<i>a</i> ₂₁	0.14	0.14	0.06	0.06
<i>a</i> 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
В	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

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)

Var	PQ _{ij} and x	PQ _{ij} increases x	PQ _{ij} decreases x	PQ _{ij} and x
	increase	decreases	increases	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
<i>PQ</i> ₁₂	7.35	7.31	0.1	0.1
PQ_{22}	6.78	6.75	0.11	0.11
<i>x</i> ₁₁	10	10	10	10
<i>x</i> ₂₁	0	0	0	0
<i>x</i> ₁₂	10	10	10	10
<i>x</i> ₂₂	0	0	0	0
<i>a</i> ₁₁	0.15	0.15	0.05	0.05
a ₂₁	0.14	0.14	0.06	0.06
<i>a</i> 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
В	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. OPTIMAL SOLUTION OF IRC FOR DIGILIB TRAFFIC WHEN α VARIABLE AND β AS PARAMETER

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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