# The New Improved Models of Single Link Internet Pricing Scheme in Multiple QoS Network

*by* Irmeilyana 30

# The New Improved Models of Single Link Internet Pricing Scheme in Multiple QoS Network

Irmeilyana, Indrawati, Fitri Maya Puspita, and Lisma Herdayana

***Abstract*—** In this paper, the new improved internet pricing scheme in multiple Qos networks will be presented. The new pricing scheme is the improved and modified from previous research. The new improved model is proposed to obtain better solution than previous results conducted by previous research. ISPs need a new pricing scheme to maximize the revenue and provide better services to customers. The models are set up by fixing the fixed base price, by varying the quality premium and user' sensitivity price. The model is considered as Mixed Integer Nonlinear Programming (MINLP) and that can be solved by LINGO 11.0 to obtain the optimal solutions. The results show that by improving the pricing scheme model, the user' sensitivity price in certain services will yield maximum profit for ISPs.

***Keywords*—** Multiple QoS network, pricing scheme, base price, quality premium.

## I. Introduction

PREVIOUS works on pricing scheme of QoS networks is due to [1-3]. They described the pricing scheme based auction to allocate QoS and maximize ISP's revenue. The solution of the optimization problem goes from single bottleneck link in the network and then they generalized into multiple bottleneck links using heuristic method. In their study, they used single QoS parameter-bandwidth. They basically formulate pricing strategy for differentiated QoS networks. In their discussion, they focus on auction algorithm to find the optimal solution. Based on their idea, it is attempted to improve and modify their mathematical formulation and combine it with mathematical formulation discussed by Byun and Chatterjee [4] (see in [5-11] ).

Recent studies have also been conducted to address problem of multiple service network, other kind of pricing scheme in network. Sain and Herpers [12] discussed problem of pricing in multiple service networks. They solve the internet pricing by transforming the model into optimization model and solved using Cplex software. Also, [13, 14] discussed the new approach and new improved model of [4, 12] and got better results in getting profit maximization of ISP.

Although QoS mechanisms are available in some researches, there are few practical QoS network. Even recently a work in this QoS network proposed by [4], it only applies simple network involving one single route from source to destination.

So, the contribution is created by improving the mathematical formulation of [1, 4] to be simpler formulation in single link by taking into consideration the utility function, base price as fixed price or variable, quality premium as fixed prices and variable, index performance, capacity in one link and also bandwidth required (see [5, 11]). The problem of internet charging scheme is considered as Mixed Integer Nonlinear Programming (MINLP) to obtain optimal solution by using LINGO 13.0 [15] software. In this part, the comparison of two models is conducted in which whether decision variable is to be fixed of user admission to the class or not. This study focuses to vary the quality premium parameters and see what decision can be made by ISP by choosing this parameter.

Our contribution will be a new modified on solving internet charging scheme in multiple QoS networks. Again, we formulate the problem as MINLP that can be solved by nonlinear programming method to obtain exact solution.

We consider cases of $\alpha$, base price to be fixed and or $\beta$, the quality premium to be fixed or vary depends on what target ISP would achieve. The Objective of ISP is also to obtain maximized.

## II. Methodology

Steps involving in this paper are as follows.

1. Determine the variables and decision parameters
2. Determine the constraints in each cases by considering to fix base price, to fix and vary quality premium and user's sensitivity price.
3. Formulate the MINLP models based on the determined parameters and constraints

Irmeilyana is with Department of Mathematics, Faculty of Mathematics and Natural Sciences, Sriwijaya University South Sumatera Indonesia (corresponding author's phone: +6281367784347; e-mail: imel_unsri@yahoo.co.id).

Indrawati, with Department of Mathematics, Faculty of Mathematics and Natural Sciences, Sriwijaya University South Sumatera Indonesia (e-mail: iin10juni@yahoo.com).

Fitri Maya Puspita is with Department of Mathematics, Faculty of Mathematics and Natural Sciences, Sriwijaya University South Sumatera Indonesia (e-mail:pipitmac140201@gmail.com).

Lisma Herdayana is with Department of Mathematics, Faculty of Mathematics and Natural Sciences, Sriwijaya University South Sumatera Indonesia.

http://dx.doi.org/10.15242/IIE.E0214513

4. Formulate each cases by setting up to fix base price, to fix and vary quality premium and user's sensitivity price.
5. Solve the MINLP models by using LINGO 11.0
6. Analyze the results and conclude.

## III. Results And Discussion

First, for obtaining the solution of the pricing scheme model, we set up the parameters and the decision variables presented in Table 1 and Table 2, respectively.

TABLE I
PARAMETERS FOR PRICING MODEL

| | | |
|---|---|---|
| | | Parameters when $\alpha_j$ and $\beta_j$ fixed |
| $Q$ | : | Total bandwidth |
| $V_i$ | : | Minimum bandwidth required by user $i$ |
| $\beta_j$ | : | Quality premium of class $j$ that has $I_j$ service performance |
| $c_j$ | : | Predetermined value of upper bound price sensitivity for user $i$ at class $j$ |
| $d_j$ | : | Maximum quality index value in class $j$ |
| | | Parameters when $\alpha_j$ fixed and $\beta_j$ vary |
| $\alpha_j$ | : | Base price for class $j$ |
| $Q$ | : | Total bandwidth |
| $V_i$ | : | Minimum bandwidth required by user $i$ |
| $c_j$ | : | Predetermined value of upper bound price sensitivity for user $i$ at class $j$ |
| $d_j$ | : | Maximum quality index value in class $j$ |
| $f_j$ | : | Minimum quality premium value for class $j$ |
| $g_j$ | : | Maximum quality premium value for class $j$ |

TABLE II
DECISION VARIABLES FOR PRICING MODEL

| | | |
|---|---|---|
| | | Decision variables when $\alpha_j$ and $\beta_j$ fixed |
| $Z_{ij}$ | = | $\begin{cases} 1, \text{if user } i \text{ is admitted to class } j \\ 0, \quad \text{otherwise} \end{cases}$ |
| $\tilde{X}_{ij}$ | : | Final bandwidth obtained by user $i$ for class $j$ |
| $L_{m_j}$ | : | Minimum bandwidth for class $j$ |
| $W_j$ | : | Price sensitivity for class $j$ |
| $X_j$ | : | Bandwidth assigned to each individual user in class $j$ |
| $\tilde{W}_{ij}$ | : | Price sensitivity for user $i$ in class $j$ |
| $I_j$ | : | Quality index of class $j$ |
| | | Decision variables when $\alpha_j$ fixed and $\beta_j$ vary |
| $Z_{ij}$ | = | $\begin{cases} 1, \text{if user } i \text{ is admitted to class } j \\ 0, \quad \text{otherwise} \end{cases}$ |
| $\tilde{X}_{ij}$ | : | Final bandwidth obtained by user $i$ for class $j$ |
| $L_{m_j}$ | : | Minimum bandwidth for class $j$ |
| $W_j$ | : | Price sensitivity for class $j$ |
| $X_j$ | : | Bandwidth assigned to each individual user in class $j$ |
| $\tilde{W}_{ij}$ | : | Price sensitivity for user $i$ in class $j$ |
| $I_j$ | : | Quality index of class $j$ |
| $\beta_j$ | : | Quality premium for class $j$ |

The pricing scheme models is already discussed in [5], so here we compare the original model proposed by [1] and improved by [5] with our improved model and our data from local server then we have solver status of three models with model 1 original of [1] and improved models of [5-8] with modification on the price sensitivity of user i in class j to be fixed price and price sensitivity for class j as variables to let the ISPs to decide how much the willingness to pay for the ISP spent for each class.

Table III and Table IV explain the solver status of the three models; original, modified with beta fixed and modified with beta vary. From our data, we have minimum bandwidth of user $i$ =1 and 2 are $V_1$=19418.96357 for traffic of files and $V_1$=400.3464254 for traffic of web in local server .

TABLE III
SOLVER STATUS OF MODEL 1 UNTUK $V_1$=19418.96357 dan $Q$=30720

| Solver status | Original | Modified (beta fixed) | Modified (beta vary) |
|---|---|---|---|
| Model Class | MINLP | MINLP | MINPL |
| State | Local optimal | Local optimal | Local optimal |
| Infeasibility | 0 | 0 | 0 |
| **Extended Solver state** | | | |
| Solver type | B & B | B & B | B & B |
| Active | 0 | 0 | 0 |
| Update interval | 2 | 2 | 2 |
| GMU(K) | 28 | 29 | 30 |
| ER(sec) | 0 | 0 | 0 |
| Best Objective | 1 | 1.05 | 1.12 |
| Objective bound | 1 | 1.05 | 1.12 |
| ESS | 0 | 0 | 0 |
| TSI | 4 | 4 | 4 |

In Table III, Generated Memory Used (GMU) shows that how much memory allocation that LINGO used to solve the model. The highest GMU is obtained in modifying the beta to vary of 30 K. Elapsed Runtime (ER) shows that the total time used to obtain and solve the models. It has effect on the number of other running application in the system. In each case, the ER is 0 sec. Extended Solver Steps depends on the certain solver that is running in the system. All models used branch and bound solver. The best model to be adopted is model with modifying the beta to be varied, since the MINLP achieves highest maximum value.

TABLE IV
SOLVER STATUS OF MODEL 1 FOR $V_1$ = 400.3464254 DAN $Q$=30720

| Solver status | Original | Modified (beta fixed) | Modified (beta vary) |
|---|---|---|---|
| Model Class | INLP | INLP | INPL |
| State | Local optimal | Local optimal | Local optimal |
| Infeasibility | 0 | 0 | 0 |
| Extended Solver state | | | |
| Solver type | B & B | B & B | B & B |
| Active | 0 | 0 | 0 |
| Update interval | 2 | 2 | 2 |
| GMU(K) | 28 | 29 | 30 |
| ER(sec) | 1 | 0 | 0 |
| Best Objective | 1 | 1.05 | 1.12 |
| Objective bound | 1 | 1.05 | 1.12 |
| ESS | 0 | 0 | 0 |
| TSI | 4 | 4 | 4 |

The highest GMU of 30K is when we have the modified with beta varies as shown in Table IV. ER= 0 sec in each case. Since all model has branch and bound solver, then ESS=0.

TABLE V
OPTIMAL SOLUTIONS MODEL 1 FOR $V_1$=19418.96357 DAN $Q$=30720

| | Original | Modified (beta fixed) | Modified (β vary) |
|---|---|---|---|
| $\alpha_1$ | 0.2 fixed | 0.2 fixed | 0.2 fixed |
| $Z_{11}$ | 1 | 1 | 1 |
| $W_1$ | 1.234568 | 0 | 0 |
| $\ddot{X}_{11}$ | 1.234568 | 1 | 1 |
| $L_1$ | 1.234568 | 0.100000E-01 | 0.100000E-01 |
| $Z_{21}$ | 1 | 1 | 1 |
| $\ddot{X}_{21}$ | 1.234568 | 1 | 1 |
| $\alpha_2$ | 0.3 fixed | 0.3 fixed | 0.3 fixed |
| $Z_{12}$ | 1 | 1 | 1 |
| $W_2$ | 1.234568 | 0 | 0 |
| $\ddot{X}_{12}$ | 1.234568 | 1 | 1 |
| $L_2$ | 1.234568 | 0.100000E-01 | 0.100000E-01 |
| $Z_{22}$ | 1 | 1 | 1 |
| $\ddot{X}_{22}$ | 1.234568 | 1 | 1 |
| $X_1$ | 1.234568 | 1 | 1 |
| $X_2$ | 1.234568 | 1 | 1 |
| $\beta_1$ | - | 0.1000000E-01 | 0.4000000E-01 |
| $\beta_2$ | - | 0.2000000E-01 | 0.3000000E-01 |
| $I_1$ | - | 0.9 | 0.9 |
| $I_2$ | - | 0.8 | 0.8 |

Table V shows the values of decision variables in three cases which are original, modified with beta is fixed and modified with beta varies. The sensitivity price for class $j$ ($w_j$) is 1.2 for each class; Each user are allowed in each class. Bandwidth for each user $i$ is 1.2 in each class where the bandwidth for class $j$ has the same value $i$th bandwidth for user $i$ which is 1.2.

TABLE VI
SOLVER STATUS DARI MODEL 1 FOR $V_2$= 400.3464254 DAN $Q$=30720

| | Original | Modified (β fixed) | Modified (β varies) |
|---|---|---|---|
| $\alpha_1$ | 0.2 fixed | 0.2 fixed | 0.2 fixed |
| $Z_{11}$ | 1 | 1 | 1 |
| $W_1$ | 1.234568 | 0 | 0 |
| $\ddot{X}_{11}$ | 1.234568 | 1 | 1 |
| $L_1$ | 1.234568 | 0.100000E-01 | 0.100000E-01 |
| $Z_{21}$ | 1 | 1 | 1 |
| $\ddot{X}_{21}$ | 1.234568 | 1 | 1 |
| $\alpha_2$ | 0.3 fixed | 0.3 fixed | 0.3 fixed |
| $Z_{12}$ | 1 | 1 | 1 |
| $W_2$ | 1.234568 | 0 | 0 |
| $\ddot{X}_{12}$ | 1.234568 | 1 | 1 |
| $L_2$ | 1.234568 | 0.100000E-01 | 0.100000E-01 |
| $Z_{22}$ | 1 | 1 | 1 |
| $\ddot{X}_{22}$ | 1.234568 | 1 | 1 |
| $X_1$ | 1.234568 | 1 | 1 |
| $X_2$ | 1.234568 | 1 | 1 |
| $\beta_1$ | - | 0.1000000E-01 | 0.4000000E-01 |
| $\beta_2$ | - | 0.2000000E-01 | 0.3000000E-01 |
| $I_1$ | - | 0.9 | 0.9 |
| $I_2$ | - | 0.8 | 0.8 |

Table VI explains the values of decision variables in three cases which are original, modified with beta is fixed and modified with beta varies. The sensitivity price for class $j$ ($w_j$) is 1.2 for each class; Each user are allowed in each class. Bandwidth for each user $i$ is 1.2 in each class where the bandwidth for class $j$ has the same value $i$th bandwidth for user $i$ which is 1.2.

From the variables decision values, we can see that for all cases of bandwidth for files traffic or web traffic, we obtain the highest maximum profit when we set up the model with base price to be fixed and quality premium to be varied. It allows the ISPs to recover cost, by fixing the base price and ISPs is also able to promote certain services to consumers. By varying the quality premium, ISPs is able to promote other services in other class, for example, in class 2 to be applied to other users.

## IV. CONCLUSION

From the results, we can see that ISP can adopt the model with modifying quality premium to be varies of 1.2. It means that ISPs can obtain highest profit by considering base price to be fixed to recover cost and beta to be varied to enable ISPs to promote certain service.

## ACKNOWLEDGMENT

The research leading to this paper was financially supported by Ministry of Higher Education Indonesia (DIKTI) for support through Hibah Bersaing Tahun I 2013/2014.

## REFERENCES


[1] Yang, W., *Pricing Network Resources in Differentiated Service Networks*, in *School of electrical and Computer Engineering*. 2004, Phd Thesis. Georgia Institute of Technology. p. 1-111.

[2] Yang, W., H. Owen, and D.M. Blough. *A Comparison of Auction and Flat Pricing for Differentiated Service Networks*. in *Proceedings of the IEEE International Conference on Communications*. 2004.

[3] Yang, W., H.L. Owen, and D.M. Blough. *Determining Differentiated Services Network Pricing Through Auctions*. in *Networking-ICN 2005, 4th International Conference on Networking April 2005 Proceedings, Part I*. 2005. Reunion Island, France, : Springer-Verlag Berlin Heidelberg.

[4] Byun, J. and S. Chatterjee. *A strategic pricing for quality of service (QoS) network business*. in *Proceedings of the Tenth Americas Conference on Information Systems*. 2004. New York.

[5] Puspita, F. M., Seman, K., Taib, B. M., & Shafii, Z., *Improved Models of Internet Charging Scheme of Single Bottleneck Link in Multi QoS Networks*. Journal of Applied Sciences, 2013. **13**(4): p. 572-579.

[6] Puspita, F.M., K. Seman, and B. Sanugi. *Internet Charging Scheme Under Multiple QoS Networks*. in *The International Conference on Numerical Analysis & Optimization (ICeMATH 2011) 6-8 June 2011*. 2011. Yogyakarta, Indonesia: Universita Ahmad dahlan, Yogyakarta.

[7] Puspita, F.M., K. Seman, and B.M. Taib. *A Comparison of Optimization of Charging Scheme in Multiple QoS Networks*. in *1st AKEPT 1st Annual Young Reseachers International Conference and Exhibition (AYRC X3 2011) Beyond 2020: Today's Young Reseacher Tomorrow's Leader 19-20 DECEMBER 2011*. 2011. PWTC, KUALA LUMPUR.

[8] Puspita, F. M., Seman, K., Taib, B. M., & Shafii, Z. *Models of Internet Charging Scheme under Multiple QoS Networks*. in *International Conferences on Mathematical Sciences and Computer Engineering 29-30 November 2012*. 2012. Kuala Lumpur, Malaysia.

[9] Puspita, F. M., Seman, K., Taib, B. M., & Shafii, Z.. *An Improved Model of Internet Pricing Scheme of Multi Service Network in Multiple Link QoS Networks*. in *The 2013 International Conference on Computer Science and Information Technology (CSIT-2013)*. 2013. Universitas Teknologi Yogyakarta.

[10] Puspita, F. M., Seman, K., Taib, B. M., & Shafii, Z.., *The Improved Formulation Models of Internet Pricing Scheme of Multiple Bottleneck Link QoS Networks with Various Link Capacity Cases*, in *Seminar Hasil Penyelidikan Sektor Pengajian Tinggi Kementerian Pendidikan Malaysia ke-3* 2013: Universiti Utara Malaysia.

[11] Puspita, F. M., Seman, K., Taib, B. M., & Shafii, Z., *Improved Models of Internet Charging Scheme of Multi bottleneck Links in Multi QoS*

*Networks.* Australian Journal of Basic and Applied Sciences, 2013. **7**(7): p. 928-937.

[12] Sain, S. and S. Herpers. *Profit Maximisation in Multi Service Networks- An Optimisation Model.* in *Proceedings of the 11th European Conference on Information Systems ECIS 2003*. 2003. Naples, Italy

[13] Puspita, F. M., Seman, K., Taib, B. M., & Shafii, Z., *A new approach of optimization model on internet charging scheme in multi service networks.* International Journal of Science and Technology, 2012. **2** (6): p. 391-394.

[14] Puspita, F. M., Seman, K., Taib, B. M., & Shafii, Z., *An improved optimization model of internet charging scheme in multi service networks.* TELKOMNIKA, 2012. **10**(3): p. 592-598.

[15] LINGO, *LINGO 13.0.2.14*. 2011, LINDO Systems, Inc: Chicago.

**Irmeilyana** received her S.Si (Undergraduate Degree in Science) in Mathematics from Bogor Agriculture Institute (IPB) Indonesia in 1997. Then she received her Master Degree in Mathematics from Bandung Technology Institute (ITB) Indonesia in 1999. She has been a Mathematics Department member at Faculty Mathematics and Natural Sciences Sriwijaya University South Sumatera Indonesia. Her research interests include Statistics, optimization and its applications.

**Indrawati** received her received her B.S. degree in Mathematics from Sriwijaya University, South Sumatera, Indonesia in 1996. Then she received M.Si in Mathematics Actuarial from Bandung Institute of Technology, Indonesia in 2004. She has been a Mathematics Department member at Faculty mathematics and Natural Sciences Sriwijaya University South Sumatera Indonesia since 1998. Her research interest includes actuarial science and its applications in insurance and risk theory.

**Fitri Maya Puspita** received her B.S. degree in Mathematics from Sriwijaya University, South Sumatera, Indonesia in 1997. Then she received her M.Sc in Mathematics from Curtin University of Technology (CUT) Western Australia in 2004. She is currently PhD candidate of Faculty of Science and Technology Islamic Science University of Malaysia (USIM), Nilai, Negeri Sembilan Darul Khusus, Malaysia. She has been a Mathematics Department member at Faculty mathematics and Natural Sciences Sriwijaya University South Sumatera Indonesia since 1998. Her research interests include optimization and its applications such as vehicle routing problems and QoS pricing and charging in third generation internet.

**Lisma Herdayana** is a student at Mathematics from Sriwijaya University, South Sumatera, Indonesia. She is currently in final stage of submission of undergraduate thesis.

# The New Improved Models of Single Link Internet Pricing Scheme in Multiple QoS Network

ORIGINALITY REPORT

| 91% | 91% | 41% | 6% |
|---|---|---|---|
| SIMILARITY INDEX | INTERNET SOURCES | PUBLICATIONS | STUDENT PAPERS |

PRIMARY SOURCES

| | | |
|---|---|---|
| 1 | iieng.org<br>Internet Source | 90% |
| 2 | "Advanced Computer and Communication Engineering Technology", Springer Science and Business Media LLC, 2015<br>Publication | 1% |

| | | | |
|---|---|---|---|
| Exclude quotes | On | Exclude matches | < 1% |
| Exclude bibliography | On | | |