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A New Approach of Optimization Model on Internet Charging Scheme in Multi Service Networks

Fitri Maya Puspita[1], Kamaruzzaman Seman[1], Bachok M Taib[1], Zurina Shafii[2]
[1]Faculty of Science and Technology, Islamic Science University of Malaysia, Nilai Negeri Sembilan Malaysia 71800
[2]Faculty of Economics and Muamalat, Islamic Science University of Malaysia, Nilai Negeri Sembilan Malaysia 71800

ABSTRACT

This paper will analyze the dynamical situation in network where new proposed pricing plans are offered with QoS networks involved. The plan is attempt to solve multi service Networks scheme as an optimization model to obtain profit maximization. Sain and Herpers [5] already attempted to obtain profit maximization by creating charging scheme of internet. We also try to obtain the solution using our analysis to also have profit maximization. Our results show that better results can be obtained by using nonlinear programming method especially for getting maximum profit.

Keywords: *charging scheme, multiple QoS networks, optimization model*

1. INTRODUCTION

Recent work on multiple service networks is due to [1]. She described the pricing scheme based auction to allocate QoS and maximize ISP's revenue. According to her, the auction pricing scheme is scalability, efficiency and fairness in sharing resources. The solution of the optimization problem goes from single bottleneck link in the network and then we generalize into multiple bottleneck links using heuristic method. In this paper, she used only single QoS parameter-bandwidth, while in networks, there are many parameters affect QoS that can be considered.

Although QoS mechanisms are available in some researches, there are few practical QoS networks. Even recently a work in this QoS network [2], it only applies simple network involving one single route from source to destination.

Yang [1] and Yang et al. [3, 4] formulate pricing strategy for differentiated service networks. In their discussion, they focus on auction algorithm to find the optimal solution. Sain and Herpers [5] also attempt to formulate the network charging scheme into optimization model and solve it to obtain maximum profit by considering the price, total network capacity to services offered and QoS levels for each service offered.

Basically, we would like to describe as follows:

- We attempt to analyze the model and result used in [5] by comparing with our result.
- We would like to give our point of view in dealing with result of [5].

2. RESEARCH METHODOLOGY

We attempt to apply optimization techniques in solving the problem in this paper. Like in [5], we also consider the optimization problem as Mixed Integer Nonlinear Programming (MINLP) that can be solved by using optimization tools. We transform the problem of pricing the internet in multiple service networks into optimization model and attempt to solve it to get optimal solution. This solution will help us interpreting the current issues involving pricing, network share, and also QoS level.

3. PREVIOUS RESEARCH ON PRICING SCHEME

The pricing schemes of the past are mainly responsive pricing that is only charging extra when network congestion indicates that the users have QoS degradation, with size of changes related to degree of congestion by comparing three different schemes for allocating a simple network resource. Firstly use no feedback and user adaptation to the network state. Secondly, use of a closed-loop form of feedback and adaptation and lastly is a closed loop variation or tight loop as it shortens the delay in the control loop [6]. Other scheme is congestion avoidance algorithm proposed by [7] and also scheme that combines congestion avoidance algorithm and one type of responsive pricing scheme that is smart market mechanism by Network Protocol proposed by [8] and [9]. One important thing why we want to create pricing mechanism is due to reducing congestion. What happens if we cannot avoid congestion? Karp [10]explains problems related to congestion and how to control it. If, for instance, there is single flow which is sending packets from source to destination, if it transmits at certain rate, it get dropped packet, but if it chooses to send other rate, it can reach destination. It gets acknowledgment from destination about the received packet. But how do we know how much .How can go through? The problem can be formulated as follows. How can the source A, for instance, know and manage its flow over continuing certain time, meaning that time is divided into duration length of time like explained in [11] and [12]. Others dealing with analysis of pricing strategy are to optimize profits, do not raise profits by guiding us to efficient pricing strategy which can control the congestion. Tuffin [13], Ros & Tuffin [14] and Odlyzko [15] also proposed Paris metro pricing scheme for charging the network. In this case, the different service class will have different price. The user has choice to choose channels to travel and price to pay. The scheme basically makes use of user to partition into classes and move to other class it found same service from other class with lower unit price. But still, they

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only consider with the case of single network which is not suitable with current internet. Meanwhile, Altmann and Chu [16] offer new pricing plan that gives benefit to ISP and users. This plan is combination of flat rate and usage based pricing. In this plan, user will get benefit from unlimited access by choosing higher QoS and at the same time ISP is able to reduce its peak load. The drawback is still due to lack of information how that plans can be adopted into multiple route networks. For the next generation internet, the availability of fast transportation of data is required. The multicast communication can decrease due to limitation of bandwidth. So we need QoS specification and compute optimal routes to a multi-constrained problem, by using greedy algorithm such as meta-heuristics algorithm, like suggested in [17].

Sain and Herpers [5] described the profit maximization model as an optimization problem by considering prices, total capacity and QoS level allocated for each service. In this paper, 3 services are offered by networks but only 2 services that can be used and allocated with gaining maximal profit.

4. RESULT AND DISCUSSION

The idea basically generates [5] and we seek to analyze their results by comparing with our results. We adopt same model, parameters and decision variables like in [5] but with differences on solver used. We process our computations by LINGO 13.0 by use of Branch and Bound solver. We choose branch and bound solver since that solver is a systematic method for implicitly enumerating all possible combinations of integer variables [18].

a. Mathematical Formulation

The tables below show the result. The problem is considered as mixed integer nonlinear programming (MINLP) since at least one of the expressions (objective function or the constraints) is nonlinear, and a subset of the variables should be integer whereas the rest is permitted to have continuous values. The solver attempts to find local optimum solution. It means that for case of that MINLP we will deal with several solutions that are locally optimal. Then the solution of that MINLP is said to be a local optimum. Also, we can convince ourselves that in finding this local optimum we may encounter problems that we will have better objective values or there is no exist such solutions. We obtain several solutions based that are locally optimal. So far, we found solutions that gives better solution on the one hand, and gives exact same solution in the other hand.

From Table 1, solution 1 and solution 2 give differences in some aspects such as in QoS level, number of concurrent users, and profit per service. We also offer 3 services both in solution 1 and solution 2. In solution 1, for profit maximization reason, service provider does not offer service 1 and 3. For service 2, a QoS level of 95% is optimal by giving 7 concurrent users to apply the service and profit of 299.25. For this service, 100% of network is reserved and used. Adding up all profits which are only service 2 yield the profit, we have 299.25 and use 4987.5 of the total capacity of 5000, which is 99.75%.

Table 1: Several Solutions of Sain and Herpers model by use of LINGO 13.0

Service	Solution 1			Solution 2		
	1	2	3	1	2	3
Share of total network capacity (a_s)	0	1	0	0	1	0
QoS level (q_s)	0.9	0.95	0.75	0.8	0.83	0.5
No. of concurrent users(X_s)	0	7	0	0	8	0
Used capacity per service ($q_s*d_s*X_s$)	0	4987.5	0	0	4980	0
Total capacity used $\sum q_s*d_s*X_s$	4987.5			4980		
Profit per service $q_s*p_s*X_s$	0	299.25	0	0	298.8	0
Total profit $\sum q_s*p_s*X_s$	299.25			298.8		

In solution 2, also for reason of profit maximization, service provider does not offer service 1 and 3. In service 2, QoS level of 83% is optimal by allowing 8 concurrent users to use the service and profit of 298.8. Also this service reserves and uses 100% of network and yield 298.8 profit and use 4980 of the total capacity of 500, which has utilization degree of 99.6%.

Since according to [5], ratio for service 2 is 0.06 that has the highest price per capacity ration so, this service is therefore offered first until the total network capacity is filled up. This applies by QoS level of 100% and there are 7 users apply at capacity 4987.5. After this service, there exists a left idle capacity of 12.5 that we cannot utilize for other services. The complete comparison between [5] and our solutions is presented in Table 2.

Table 2: Result Comparison between Sain and Herpers [5] and our Result

	Sain and Herpers[5]			Solution 1			Solution 2		
Service	1	2	3	1	2	3	1	2	3
Share of total network capacity (a_s)	0.1	0.9	0	0	1	0	0	1	0
QoS level (q_s)	0.8	1	0.5	0.9	0.95	0.75	0.8	0.83	0.5
No. of concurrent users(X_s)	10	6	0	0	7	0	0	8	0
Used capacity per service ($q_s*d_s*X_s$)	480	4500	0	0	4987.5	0	0	4980	0
Total capacity used $\sum q_s*d_s*X_s$	4980			4987.5			4980		
Profit per service $q_s*p_s*X_s$	24	270	0	0	299.25	0	0	298.8	0
Total profit $\sum q_s*p_s*X_s$	294			299.25			298.8		

If we see from total capacity used, solution 1 achieves better solution than solution 2, since it equals to utilization degree of 99.75% while in solution 2, the utilization degree of 99.6% got the same result in [5]. Also, solution 1 gives better result compared to [5].

Solution 1 is obtained by gaining Generated Memory Used (GMU) = 25 K and Elapsed Runtime (ER) = 1 sec with Extended Solver Steps (ESS) = 4 and Total Solver Iterations (TSI)=115. Meanwhile, for solution 2, GMU is 24 K, ER=0 sec, ESS=1 and TSI = 28. If we compare for computational time to achieve the solution, solution 2 yield better computational time since it only take 28 iterations, but solution 1 takes 115 iterations as we can see from Table 3.

Table 3: Solver Status of Solution 1 and 2 using LINGO 13.0

Solver Status	Solution 1	Solution 2
Model Class	MINLP	MINLP
State	Local Optimal	Local Optimal
Objective	300	300
Infeasibility	0	0
Iterations	115	28
Extended Solver Status		
Solver Type	Branch and Bound	Branch and Bound
Best Objective	300	300
Objective Bound	300	300
Steps	4	1
Update Interval	2	2
Generated Memory Used	25	24
Elapsed Time	1	0

Finally, what ISP consider is better profit with saving computational time with only has slight different values of objective function (equals to 0.45).

From our point of view, however, since we consider the provider profit, our result is better than in Sain and Herpers [5] results. Our results gain better profit, but have differences in numbers of service offered. In [5], they have 2 services offered with total number of users, while in our approach we only apply one service offered.

5. CONCLUDING REMARK

The model shows the connection between pricing, QoS level, number of user applying the services, capacity allocation and total network share. But due to assumptions, we only see the results as a theoretical point of view as a static model that is unlikely difficult to adapt to dynamic situation.

The paper shown by [5] can be more upgraded by using our new approach using other tools. We obtain slightly increasing profit in several solutions we proposed. We also save human resources by only applying few users to apply the service and also we can save energy by only promote one service rather than two services. Our solutions show better profit with less idle time and number of users applied the services.

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