CHAPTER I
INTRODUCTION

1.1 Overview

The Internet nowadays is becoming essential to the global economy. Experimental research networks and economic activities have been created for all walks of life. It is a tremendous task for ISPs to promote good service towards achieving high quality information and gain profits from available resources. Providing better and different QoS is the best way to improve revenue. Furthermore, other parties will be able to apply these schemes to develop new ICT based products. However, a proper pricing mechanism needed by network service providers in order to provide logical and convincing technical solutions for customers is currently lacking.

First, the concepts of pricing scheme, optimal solution of mixed integer nonlinear programming, multiple service networks, multiple QoS networks are introduced.

1.1.1 Pricing scheme

Pricing products or services is the critical business decision or core activity that has to be discussed in this research. The products should be offered at a price that our target market is willing to pay. The important role to achieve the internet efficiency in terms of economics point of view is by conducting pricing. Pricing are proposed not only to recover cost but also the ability to allow consumers selecting the service. There are several approaches to pricing schemes, both involving scientific and non-scientific methods (Hallberg, 2007). Pricing schemes refer to mechanisms to manage the resource allocation available. Pricing schemes are critical issues in current internet networks. Nowadays, Telcos face a great challenge in managing appropriate pricing plans in these dynamical networks. Ferreira (2002) and Ferreira & Viennot (2002) contended that with

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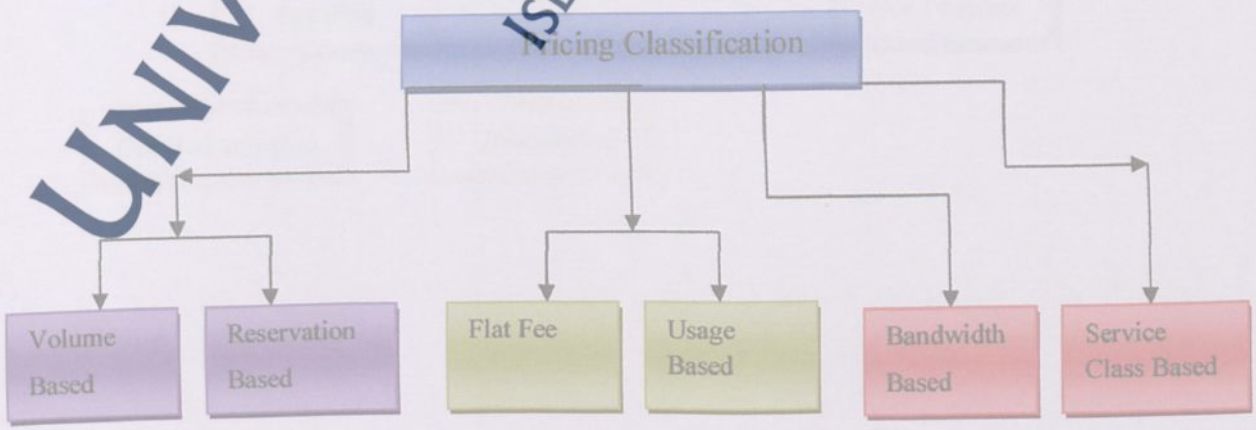
precise pricing plans, Telcos are able to control congestion, maintain resources such as bandwidth, delay, etc. optimally while satisfying customer demand and gaining optimal profit.

Wu et al. (2002) described the optimal pricing scheme, both from the consumer's and supplier's perspectives. They viewed three pricing schemes, such as the flat fee, pure usage-based and two-part tariff scheme. In their paper, they analyzed the situation where providers could gain better profits if they choose one pricing scheme and how much it charges. When it is said that providers obtain optimal or maximal profits, it does not mean that the providers get the highest profits but rather they can maximize their resources for optimal function. The analysis of the pricing strategy is divided into two parts; one is by considering the homogenous customers and the other, the heterogeneous customers. In the homogenous case, all customers have the same utility on consumption level per day while in the heterogeneous case, customers have two segments according to their willingness to pay and level of usage.

Sain (2001) also considered four pricing schemes namely the flat rate, usage-based, transaction-based, and version-based. He analyzed the pricing strategy by grouping it into two parts: the one-component and two-component strategy and showed that the usage-based pricing is more efficient than one-component pricing strategy by giving examples of well-known communication network companies around the world.

Stiller et al. (2001) classified the pricing mechanisms by combining the three fundamental tariff elements i.e. set up cost, access and usage charges as shown in Figure 1.

FIGURE 1: Pricing Classification by Stiller et al (2001)



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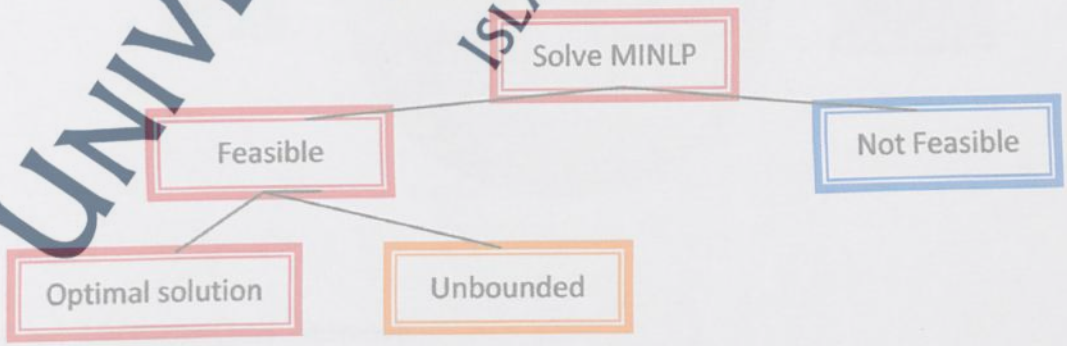
Meanwhile, Altmann & Chu (2001) offered new pricing plan that benefits ISPs and users. This plan is a combination of flat rate and usage based pricing. In this plan, the user will benefit from unlimited access by choosing higher QoS and at the same time, the ISP is able to reduce its peak load. The drawback is still due to the lack of information on how the plans can be adopted into multiple route networks.

1.1.2 Optimal Solution of Mixed Integer Nonlinear Programming Problem

When dealing with pricing schemes, some techniques should be introduced to solve those pricing schemes. Optimal solution from the pricing schemes refers to specific notion to maximization which is the knowledge to utilize the best use of scarce resources in the network (Dixit, 1990). Pricing schemes that work on multiple QoS networks refer to pricing schemes that work on networks that serve multi QoS parameters such as bandwidth, delay, jitter and packet loss.

Figure 2 shows the solution outcomes of MINLP (Schrage, 2009). If properly formulated, then the path with the same color will be chosen. The procedure steps are as follows. First, the procedure will seek the feasible solution which is satisfies all constraints simultaneously. If two or more constraints are violated then the path of no feasible solution will be chosen. For example, the constraint pair $x \leq 4$ and $x \geq 5$ explains the no feasible solution path. A local optimal solution occurs if there is no existence of better solution nearby.

FIGURE 2: The Solution Outcomes of MINLP (Schrage, 2009)



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1.1.3 Multiple Service Network

Bouras & Sevasti (2004), Byun & Chatterjee (2004) and Reichl et al. (1999) stated that pricing has become a very interesting topic in network business. In supporting this business, the internet has to provide the best QoS to allow differentiation of network services based on their unique service requirements. Byun & Chatterjee (2004) discussed designing pricing models for internet services at various levels of quality, which focuses on a usage based pricing scheme since that scheme reflects congestion levels in detail.

Gupta et al. (1995) argued that future computer networks will provide a variety of services with a set of users applying the services. Numerous work has been conducted by network researchers to tackle network resources such as routers, links and communication protocols efficiently. They described the fundamental illustration of multiservice networks, where the users might be on one server while accessing services on other servers. The users might also provide the services to other servers or users. Figure 2 briefly illustrates multiservice networks. A single network indicates that users can only have single interface to a communication network to enable them to access any application.

FIGURE 3: A Multiservice Integrated Network (Gupta et al., 1995)

1.1.4 Multiple QoS Network

Yang (2004) had previously done some work on multiple QoS networks and she described the auction-pricing scheme to allocate QoS and maximize ISP's revenue.

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According to her, the auction-pricing scheme is scalable, efficient and fair in sharing resources. The solution for the optimization problem starts with the single bottleneck link in the network and is then generalized into multiple bottleneck links, using the heuristic method. In her paper, she only used the single QoS parameter-bandwidth, while in the networks, there are many parameters that affect the QoS that can be considered.

Although QoS mechanisms are available in some researches, there are only a few practical QoS networks discussed such as pricing strategies proposed by Byun & Chatterjee (2004), Sain & Herpers (2003), Yang (2004), Yang et al. (2004;2005).

Based on previous research and observation, there were some motivating factors that encouraged us to conduct this research. Firstly, there is only a few of research on multiple QoS networks, which is a critical issue in internet charging framework. Packets usually are dropped if there are no classes to classify the users applying the internet. ISP needs to set up plans to classify users according to their budget and preferences in using the internet as the service with the best quality will receive higher prices.

Secondly, ISPs face a challenging problem due to user's preference towards a flat rate plan (Wu & Banker, 2010). This plan does not create many benefits for the ISPs and the problem dealing with dropped packets is also unsolved. That is why ISPs should come up with an idea for a new pricing plan that classifies the pricing scheme into classes in each link.

1.2 Problem Statements

Due to scarcity research on multiple networks applied to pricing schemes to obtain optimal pricing strategy, where actually this issue remains critical especially as ISPs now are dealing with the goals to get maximum revenue and to satisfy the user's satisfactions.

The purpose of this research is to formulate new pricing schemes for multiple QoS networks that work dynamically depending on the parameter of networks needed

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by ISP. The proposed new pricing schemes will be the option for ISP to implement the policy in achieving the maximum profit. Telcos face challenging problems due to user's preferences on flat rate pricing. Telcos develop multiple class QoS networks to give customers a choice in choosing the service. However, telcos are having difficulty in coming out with the right pricing schemes with this multiple class QoS networks. A number of researches have been done in this area. However, the lack of information on how pricing schemes can be applied on multiple networks is not explained. So, the new improved mixed integer nonlinear programming models are prepared in formulating the new pricing schemes by designing the pricing schemes to be solved numerically using LINGO 11.0.

The analysis is divided into two parts; the new pricing schemes for multi service networks and for multi QoS networks. For each network, the optimization approach is used by modeling the schemes into MINLP and is solved numerically by application software LINGO 11.0. The goals of ISP are to maximize the profit such as to recover cost while promoting certain service, recover cost while user can select service, to have market competition while user can select the service or to have market competition while promote certain services. The MINLP solutions show the intended ISP's goals.

1.3 Objectives of the Research

The objectives of this research are to:

i. Formulate new optimal pricing schemes in multiple class QoS networks.
ii. Propose the new improved pricing schemes that work dynamically in multiple QoS networks.
iii. Determine the solutions of internet pricing scheme for multi service networks and multi QoS network.

Table 1 summarizes the objectives and the method used to achieve the objectives.

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TABLE 1: Objectives and the Method Used to Achieve the Objectives

Objective	Methods Used to Achieve The objective
The aim of this research is to formulate a new optimal pricing scheme under multiple class QoS networks. The model for internet pricing from a single bottleneck link is built then generalization of models into multiple bottleneck links is generated. First, models are generated from multiservice multiple bottleneck links. Second, models are generated from multiple class QoS multiple bottleneck links To analyze the optimal pricing scheme under multiple class QoS networks	1. Study existing internet pricing schemes for single link and multiple bottleneck links 2. Identify the parameters and variables involved in existing models to enable it to be adopted into new proposed models. 3. Seek requirements/conditions that satisfy the new proposed model, such as QoS requirements, bandwidth, base price and quality index. 4. Solve all these models by formulating the models into optimization problems (Mixed Integer Nonlinear Programming) and solve it iteratively by using optimization tools (LINGO 11.0)
To propose pricing scheme that set an advantage to telcos and determine the optimal solution for each scheme	1. Propose new models based on above information: - New approach to existing model in multiservice single link network - Improved models in multiservice single link network - Improved models in multiservice class multiple bottleneck link networks - Improved models in multiple class QoS single link networks - Improved models in multiple class QoS multiple link networks 2. The efficacy of the newly proposed models have to be proven (better benefits) to the telcos by indicating - Better profit for internet/service providers - Clearly state the admission for users in each class of service - Internet providers have options to choose which plan to adopt according to models proposed 3. The solution is obtained for each scheme to inform ISPs that new pricing scheme proposed is better than previous research.

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1.4 Research Question

Since telcos are having difficulties in coming up with the right pricing scheme with this multiple class QoS networks then question of how to optimize internet pricing, taking into account multiple QoS networks.

To set up price, ISPs should be aware that service quality affects the willingness of the users to use the product. But, ISP cannot improve service quality infinitely since there are limited network resources such as bandwidth, capacity, delay, jitter and usage. So the research question is how to optimize the profit by considering the limited availability of network resources.

1.5 Scope of the Research and its Limitations

In this research, the pricing schemes proposed are based on Telcos that are concerned with wired networks and the advantages of new pricing schemes are to maximize profits according to the Telcos perspective.

The MINLP formulations for multiservice networks are limited only for 3 services offered. Meanwhile, for multiple QoS networks, the MINLP formulations are limited only for 2 users in single bottleneck link, and 2 users and 2 links in multiple bottleneck links.

1.6 Target Audience and Expected Outcomes of the Research

The target audiences will be ISPs and Telcos and the expected outcomes are:

i. Improved mathematical models under multiple service networks to maximize ISP profit.
ii. Improved mathematical models under multiple class QoS networks to maximize ISP profit.

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1.7 Organization of the Thesis

This thesis is organized into six (6) related chapters. Chapter I presents the introduction of the project, beginning with description of the research definition, research objectives, scope of the research and limitations, target audiences, expected outcomes of the research and organization of this project.

Chapter II will be the literature review, which scrutinises previous research and observations and discussions by other authors that assists the researcher to determine the remaining problems associated with the current internet-charging scheme.

Chapter III describes the methodology of the research by explaining the process of the research and the optimization tools used to help in the computation.

Chapter IV discusses the first contribution of the research that deals with the new approach in solving the existing pricing scheme model proposed by the Sain & Herpers model (2003) and also the new improved model originally proposed by Sain & Herpers (2003) in solving internet pricing schemes in single and multiple links under multiple service networks.

Chapter V discusses the second contribution of the research in terms of the new improved model for internet pricing schemes in multiple class QoS networks and a brief conclusion about that second contribution.

Chapter VI concludes the whole thesis that focuses on the advantages and benefits of our proposed model and describes the future work after this research.

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