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QUALIT TRADE-OFF BETWEEN PRICE AND QUALITY OF SERVICE IN NEXT GENERATION NETWORKS

Abstract: *As broadband access penetration increases and new applications emerge, the question of how to deliver services with guaranteed quality, along with the mechanisms for pricing these services has become increasingly important. In this paper we propose the model for pricing next generation networks services. We consider the competition between two service providers offering the same service. The model includes trade-off between quality of service and price. The model is verified through numerous simulations.*
Keywords: *Competitive pricing, Quality of service, Next generation networks, Certainty equivalent.*

1. INTRODUCTION

Among many issues, the issue of pricing services with Quality of Service (QoS) guarantees induced significant increase of interest in telecommunication networks over the last decade. This has led to a new interdisciplinary research area of "Telecommunication Economics", which investigates telecommunication networks from an economical rather than from a technical perspective and allows innovative solutions in network management, control and pricing [5].

Next Generation Networks (NGN) are packet-based networks that should be operated by large number of service providers (SPs) [7]. The SPs compete with each other for users and traffic, while at the same time they have to cooperate and exchange traffic.

Many SPs are looking to NGN services as a means to attract and/or retain the most gainful users. There are two main characteristics of providing services in NGN: price and quality. Therefore, it is important to investigate pricing issue and QoS in NGN.

In NGN users are expected to choose the service provider offering the best price and QoS combination. As a result, SPs operating in the same telecommunication market will end up competing for the users by adjusting the QoS they offer and the price they charge for their services.

In this paper we propose the model for determining revenues of two competitive SPs which includes trade-off between utility which is directly proportional to obtained quality of service and price for users that are classified according to willingness to risk.

This paper is organized in the following way. In Section 2 we discuss QoS performance dimensions and requirements for pricing QoS-enabled services in NGN. In Section 3 we explained the difference between three types of users classified according to willingness to risk. In Section 4 we propose the competitive model between two SPs with specific utility functions based on QoS for each user's type. In the same Section we presented and analyzed simulation results. Concluding remarks are given in the Section 5.

2. QUALITY OF SERVICE AND PRICING REQUIREMENTS IN NGN

In this Section we will firstly introduce some fundamental definitions in NGN. Unlike many previous environments where only one simple relationship between the party supplying the service and the party using the service existed, the NGN environment enables an arbitrary recursion of these relationships. The following definitions from M.3050.1 have been adopted [8]:

User or end user is a human being, organization, or telecommunications system that accesses the network in order to communicate via the services provided by the network. The end user is the actual user of the products or services offered by the enterprise.

Network provider (NP) represents the organization that maintains and operates the network components to support services. A network provider may also take more than one role, e.g. also acting as SP.

Service provider is a general reference to an operator that provides NGN telecommunication services to users either on a tariff or contract basis. SP may or may not operate a network or be a user of another service. NGN should provide charging interfaces among SPs and NPs.

The most important characteristics of NGN are the extraordinary expansion of digital traffic and a distinct need to converge and optimise the operating networks. The evolution of networks to NGNs must allow the continuity of, and interoperability with, existing networks while enabling the implementation of new capabilities [7]. Any NGN architecture must guarantee fair access to shared resources in the access network and control load distribution with aim of avoiding focused overload in the core. Also, NGN should support hard guarantees to users and pricing of different QoS classes.

Due to the rapidly increasing deployment of interactive and multimedia applications in communication services, QoS becomes an integral part of various protocols, mechanisms and services in enabling computing and communication systems [16].

QoS is defined by the bilateral contract or agreement (SLA, Service Level Agreements) between two interconnected parties. Although QoS is usually represented by the delay, jitter, and loss, they are not reliable and very difficult to measure precisely [2]. Therefore, frequently used QoS parameters for determination whether a required service level is being achieved, are network availability and bandwidth.

Network availability can have a significant effect on QoS. For example, if the network is unavailable, even during brief time intervals, the user may achieve unpredictable and/or undesirable performance. Network availability includes the availability of many items the network consists of, e.g. multiple physical connections, networking device redundancy, etc [9]. NPs can increase their network's availability by implementing varying degrees of each of these items.

Another significant QoS parameter is bandwidth. It is important to distinguish available and guaranteed bandwidth. In many dynamic pricing schemes users are allowed to compete for the available bandwidth and their obtained bandwidth depends upon amount of traffic from other users in the network at any observed time [3]. The term guaranteed bandwidth implies a guaranteed minimum bandwidth NP provides or burst bandwidth in SLA. The service with guaranteed bandwidth has higher priority and is priced higher compared to the available bandwidth service [1, 17]. Burst bandwidth can be defined as an amount or duration of excess bandwidth above the guaranteed minimum. Different applications can have very different bandwidth requirements (e.g. e-mail, VoIP and streaming audio have low bandwidth requirements, while video conferencing and streaming video on demand have high bandwidth requirements [9]).

Pricing schemes that should be implemented in NGN have to be defined and evaluated with respect to the heterogeneous technical, economic and social aspects. The main evaluation criteria encompass efficiency in the context of maximizing utilities of users and the provider, fairness and feasibility [10, 12, 13, 15]. The main NGN requirements for pricing are:

- Off-line (i.e. post processing) and on-line charging (i.e. charging during the session), should be available.
- Open mechanisms should be available for charging and billing management.
- Various charging and billing policies should be supported (e.g. fixed rate charging and usage based per-session charging and billing).
- Accounting functions should support services with multicast functionality.
- NGN should enable all possible types of accounting arrangements.

In NGN there is a need for shifting from simple charging schemes such as static pricing schemes towards dynamic pricing schemes [4]. In dynamic pricing, tariff is determined as a cost per unit of consumption and according to level of QoS guarantees provided for the observed service class. The main problem with dynamic pricing refers to the need of intensive monitoring of network resources in order to dynamically adjust per-class prices to resources usage and the QoS provided for each service class [6].

3. QUALITY vs. PRICE FOR DIFFERENT TYPES OF NGN USERS

According to willingness to risk [11, 14] in a relation between QoS and price, NGN users can be classified into three categories. Users that are willing to risk received QoS during the congestion time will be charged less compared to users that are not willing to risk QoS. There is also a category of risk neutral users that are neutral toward risk. Therefore, utility which is directly proportional to obtained QoS can be defined as a function of price such that:

- $U(P)=e^{\gamma P}$ denotes utility as a function of price for a not willing to risk user and it is convex function (Figure 1).
- $U(P)=\gamma P$ denotes utility as a function of price for a risk neutral user and it is linear function (Figure 2).
- $U(P)=\ln(\gamma P)$ denotes utility as a function of price for a willing to risk user and it is concave function (Figure 3).

In all defined QoS functions γ is parameter such that $\gamma > 0$.

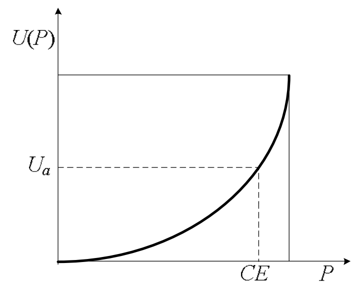

***Figure 1** – Utility function for not willing to risk users*

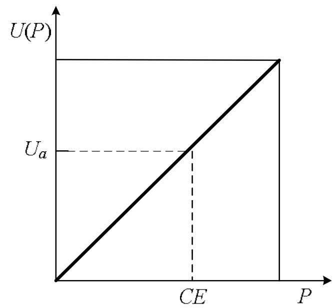

***Figure 2** – Utility function for risk neutral users*

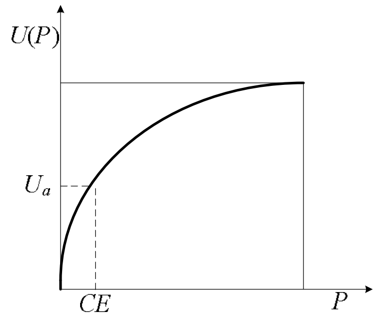

***Figure 3** – Utility function for willing to risk users*

In Figures 1, 2 and 3, the difference between defined types of users can be observed through user's willingness to pay the price that matches average utility U_a – certainty equivalent (*CE*). *CE* is highest for a not willing to risk user and it takes the lowest value for a willing to risk user.

4. COMPETITIVE MODEL AND SIMULATION RESULTS

In this Section we propose the model for determining prices of two competitive SPs.

We examined previously defined utility functions for the case with specific range of prices: $P \in [1; 2.8]$. For this range of prices and $\gamma = 1$ we obtained new relations between QoS-based utility functions and price as it is shown in Figure 4.

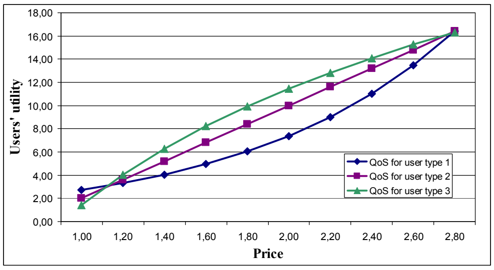

Figure 4 – Utility functions for three types of users

Mathematical expressions of utility functions shown in Figure 4 are:

1. $U(P) = e^{\gamma P}$, for a not willing to risk user – user's type 1
2. $U(P) = 8\gamma P - 6$, for a risk neutral user – user's type 2 and
3. $U(P) = 14.5\ln(\gamma P) + 1.4$, for a willing to risk user – user's type 3.

In this example, the class of service with average QoS guarantees corresponds to the value *U*=8.5. Certainty equivalent values for defined types of users are: CE_1=2.14, CE_2=1.81 and CE_3=1.63, for user's type 1, 2 and 3, respectively.

We assumed two service providers with different positions in the same NGN market: SP_1 is the provider with high reputation and SP_2 is the new service provider who is just entering the NGN market. We considered only the revenues both SPs obtain providing the same NGN service. In that case, SP_i (*i*=1, 2) revenue can be defined as a function of number of users and price. If observed service gives average QoS guarantees, then all users pay the price *CE*. In that case, SP_i revenue is:

$$T_i = \sum_{j=1}^{J} N_{ij} CE_{ij} \qquad (1)$$

We made certain assumptions:

- The total number of users is *N*=100;
- SP_1 has equal number of not willing to risk users and risk neutral users and
- SP_2 can attract only willing to risk users.

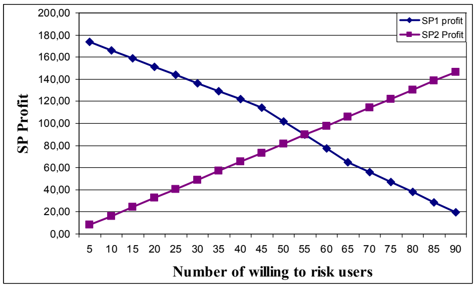

***Figure 5** –Revenue functions for two competitive SPs*

If users are allocated so that the

number of type 1 users is N_1=25, the number of type 2 users is N_2=25 and the number of type 3 users is N_3=50, SP_1 revenue is T_1=98.75, which is higher than SP_2 revenue T_2=81.5.

More general observation includes variations of number of users belonging to certain risk type, which is shown in Figure 5.

Revenues of these two SPs equals for N_1=25, N_2=20 and N_3=55. If SP_2 manages to attract more than 55 percent of total users, he will obtain higher revenues compare to SP_1, although all of his users are priced less (i.e. willing to risk users).

5. CONCLUSIONS

In this paper we propose competitive pricing model for determining revenues of two SPs operating in NGN environment, assuming different distribution of users classified according to willingness to risk. In this paper we considered only the revenues both SPs obtain providing the same NGN service.

The first aim of our research was to analyze difference between certainty equivalent values for users with different willingness to risk. Second focus in our research was the analyses of revenue changes depending on the number of users willing, unwilling and neutral to risk. Willing to risk users have higher certainty equivalent value compare to risk neutral users and not willing to risk users, as we expected. Simulation results also showed that SP who attracts only not willing to risk users can achieve higher revenues than his opponent under certain conditions.

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