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A NEW COMPETITIVE MODEL BASED ON TRADE-OF BETWEEN CREDIBILITY AND PRICE

***Abstract**. This paper proposes a new pricing model for competitive service providers in next generation network market. It includes demand function based on service provider's reputation and service price. In order to determine trade-off between price and reputation, service provider's profit as a function of both price and reputation parameters has been proposed. The model considers economic interactions between two competitive service providers with the same service offers. With the goal of choosing the best pricing strategies for each service provider Nash equilibrium has been found. This model could be very useful for optimizing service provider's profit by adjusting service price according to its reputation. Through numerical examples, performances of the proposed model have been examined.*

Key words: *Competition, demand, Nash equilibrium, next generation networks, reputation, service price, service provider.*

JEL Classification: R34, D43, D58, C70

1. INTRODUCTION

The Next Generation Networks (NGN) can be seen as an assembly of different autonomous networks operated by separated authorities (multi-operators) (ITU, 2005). Competitive Service Providers (SPs) in NGN markets should provide the infrastructure which support services at lowest possible prices and with guaranteed Quality of Service (QoS) compared to the existing services, with their simultaneous reliability and compliance with standards. A NGN user is free to choose among multiple SPs competing with each other and cooperating at the same time while offering variety of services. The openness of NGN to different SPs facilitates and accelerates launching of new services, which will make it possible for users to take part in creating the service and to create their own services.

With increasing competition in telecommunication markets, it will be essential for SPs to position themselves appropriately and to prepare for the emerging NGN environment. By means of pricing policy SPs strive to achieve better market position. An efficient SP prefers pricing concept which enables not only to maximize its profit but also to attract more users by offering lower prices with end-to-end QoS guarantees.

The challenge of providers today exists due to user perspectives. Users' loyalty as part of users' behaviour can significantly affect the SPs price setting strategies (Biczok et al., 2008), (Chiou, 2004), (Gyarmati and Trinh, 2009). SP with higher reputation will clearly attract more users. Therefore, concept of reputation is very important for each SP in NGN. NGN providers will also face some difficult decisions regarding service prices.

Our competitive model includes complex demand function concerning to reputation parameter and service price. The model can be useful for studying economic interactions of service providers offering the same service. The solution of the defined problem is based on Nash equilibrium concept. The proposed model determines optimal service prices for two competitive NGN providers with different reputations in a sequence of discrete times. The model is verified throughout the experimental results encompassing Nash equilibrium prices for two SPs offering Internet Protocol Television (IPTV) service in the Serbian broadband market.

The rest of the paper is organized as follows. Section 2 discuses about the competition of SPs and highlights the importance of SP's credibility in NGN. In Section 3 we propose the new competitive model with demand function based on SP's credibility and service price. In the same Section the SPs' behaviour concerning profit function is considered. The experimental results including Nash equilibrium prices for two competitive SPs are analyzed in Section 4. The contributions of this paper are summarized and the future research is suggested in Section 5.

2. NGN SERVICE PROVIDERS COMPETITION

As traditional networks evolve towards NGN, the distinction among service providers becomes more evident. The service providers compete to offer the variety of services to the users while maximizing their profits. Using the trade-off concepts, we characterize the SP price competition game and show that in the optimal solution each provider has its own customer base. A user may choose a provider with a lower reputation if the price of the service is low enough, or conversely choose a more credible provider with greater service price. The providers select their prices to maximize their revenues, keeping in mind the impact of prices on their users' demand.

Economists have traditionally employed game theory to analyze the behaviour of users in markets regulated by supply and demand. Also, game theory is a good basis for the analysis different pricing problems in NGN (Altman and Wynter, 2004; Chen and Pau, 2009; Courcoubetis and Weber, 2003; Ji et al., 2008; Radonjić and Aćimović-Raspopović, 2009; Radonjić and Aćimović-Raspopović, 2010). The problems of demand and routing control are jointly solved by achieving equilibrium in a proposed pricing mechanism (Masuda, 2002). Nash equilibrium is the well known concept for finding solutions in game theory and implies that each player chooses its best strategy analyzing all other players' strategies. Nash equilibrium is a state of the game where each player cannot profit from changing his own strategy and since the players are rational, no player prefers a different strategy if the current strategies of other players are fixed (Osborne, 2004; Mansour, 2006). In Altman and Wynter (2004) the existence of Nash equilibrium for two-level pricing problem is discussed. The pricing model based on cooperative game in which the Internet service prices are used as a means of encouraging providers to cooperate and innovate services was proposed in He and Walrand (2006). For solving problems of routing and pricing in mobile ad hoc networks, the authors in Ji et al. (2008) proposed a model that consists of multiple interrelated games in which the goal of maximizing profit is achieved if Nash equilibrium in each game exists.

In NGN environment, where traffic with QoS guarantees can be carried end to end by two or more providers, new settlement models are expected to start up (ITU-T E.800, 2009). However, it appears that in NGN QoS differentiation will not provide a suitable economic framework for the trade-off between quality delivered by the SP and willingness to pay from the user's side. Quality of Experience (QoE) is an alternative framework for pricing service quality according to the user perception (Reichl and Hammer, 2006). It depends upon user actions and subjective opinions and includes the complete end-to-end system effects (client, terminal, network, services infrastructure, etc). QoE, also referred to as "perceptual QoS", is defined as "a measure of the overall acceptability of an application or service, as perceived subjectively by the end-user" (ITU, 2005; ITU-T D.197, 2004). In this paper we introduce users' sensitivity to the service price variation as a QoE parameter.

We consider the SPs that attract different types of users who connect to the network, purchasing services from them. The market consists of many potential users that could be attracted based on provider reputation. In this paper we introduce the credibility function that is related to the reputation of the NGN providers. SP's reputation has either confirmed its existence in market or described in general terms its effects upon other attributes such as quality of service, price, advertising, etc. (Herbig et al., 1994). It is assumed that the SP's reputation is the main decision factor regarding the SPs selection. The difference between reputable and non-reputable SP is identified according to certain situations faced by users satisfaction related with service price, QoS, advertising efforts, representatives of a provider etc.

The credibility of an early service announcement affects the decision of users with regard to its adoption (Brockhoff and Rao, 1993). Information about the introducing a new service are not always trustworthy. Users know that vaporware is a common practice in some industries and that many preannounce services are introduced after a very long delay. For instance, 47% of sample of software services have been launched with a delay over three months compared to their announced release date (Shapiro, 1983). Users also know that some preannounced services are never introduced in the market and that others are launched with very different features from the ones originally announced. Users thus question the credibility of the information received about forthcoming services, whether it comes from the media or from people they know. We used a credibility factor that mediates the effect of communication on adoption of a service. For the sake of simplicity, we consider the credibility of both sources of communication to be similar. Some may argue that the information spread by word-of-mouth is more trustworthy than the news published in the media. We do not make any such distinction here. We consider here the credibility function related to the reputation of the provider and to the time before the selection of the provider is made. A good reputation of providers speeds the diffusion of innovations for two reasons: (1) reputation enhances the relationship and confidence that exist between providers and potential users, and (2) a high reputation and credibility of the provider reduce uncertainty about a new service. In Shapiro (1983) it is shown that the higher reputation of the provider, the more credible is the announcement.

3. A NEW PRICING MODEL FOR COMPETITIVE SERVICE PROVIDERS IN NGN

We consider the scenario with two service providers that compete in the NGN market. The competitive behaviour is based on SP`s reputation and service price. The different situations that could be obtained in the market are analyzed. Each SP has to select its price setting strategies based on the costs of service providing, its credibility and the current market demands. By reducing the service price, SP has the opportunity to attract the new users and compensates its weak reputation. The dynamic of the SP market is changed depending on those parameters. In this paper, the considered problem is simplified by assuming that service offer related with QoS is the same for both SPs. Finally, NGN users are expected to choose the service provider based on the price and the reputation. This study uses applied game theory and computer simulation for analyzing market dynamic based on indicators variations. The solution of the considered problem with the goal of maximizing SPs profit is achieved if Nash equilibrium exists. In the following section we propose a new competition model for SPs selection in NGN environment.

3.1 The Credibility Function

The SPs credibility, $C(t, \lambda_r)$, can be formulated as a function of time before the service provider selection is made, t and the provider's reputation parameter, λ_r:

$$C(t, \lambda_r) = e^{-\lambda_r \cdot t} \tag{1}$$

where $\lambda_r \geq 0$ and $0<C(t, \lambda_r) \leq 1$ as long as $t>0$. When the SP's reputation parameter decreases, the credibility function gets higher (Brockhoff and Rao, 1993). Consequently, credibility increases as the time remaining to service introducing (or selection of SP) gets closer:

$$\frac{dC(t)}{dt} = -\lambda_r e^{-\lambda_r \cdot t} \leq 0 \tag{2}$$

We use the parameter λ_r to reflect the reputation, r. Actually, we define the reputation parameter, λ_r, as the inverse function of the SP's reputation, r. When λ_r gets smaller then the reputation increases, i.e.

$$\frac{d\lambda_r(t)}{dr} \leq 0 \; for \; \lambda_r \geq 0 \tag{3}$$

If the remaining time to a service provider selection is shorter, the credibility function is increased. When the time before selection gets longer, credibility decreases rapidly. Equation (2) corresponds to the fact that provider with lower credibility (higher λ_r) has to make advertising efforts for a longer time to achieve the same credibility.

3.2 The Demand Function based on Credibility and Price

Demand for a service has great influence on SP's profit. Therefore, it is important to determine total demand for the service for each provider. Total users' demand includes the cumulative function of users, which is actually users' satisfaction probability to accept a service depending on trade-off between the credibility and price and total market potential. Therefore, the demand is a function of the reputation parameter and the price. The demand function, *D(t),* defined in this section, incorporates both, the credibility function and the service price, by the following equation:

$$D(t) = F(t)\, m = \left(1 - e^{-P^A}\right) C(t, \lambda_r)\, m = \left(1 - e^{-P^A}\right) e^{-\lambda_r t}\, m \tag{4}$$

where:

F(t) - the cumulative function of users, $0 \leq F(t) \leq 1$;

m – the market potential;

t – time to SP selection, $t>0$;

P– the service price;

A – users' sensitivity to the service price variation defined as a QoE parameter;

$C(t, \lambda_r)$ – the credibility function, $0 < C \leq 1$;

λ_r – the reputation parameter.

An illustration of the combined impact of the reputation parameter and time on demand function (m=500.000, M=0.5 and A=–3.5) is shown by Figure 1. The values of users' sensitivity to the service price variation and the market potential are estimated for residential broadband market in Serbia (Kostić-Ljubisavljević et al., 2007; Radojicic et al., 2011). It is obvious that the credibility of the provider is increased as the time of selection SP gets shorter. The same effect occurs in the demand function. We present this effect on five levels of reputation parameters: very high credibility (λ_r=0.1), high credibility (λ_r=0.2), medium credibility (λ_r=0.3), low credibility (λ_r=0.4) and very low credibility (λ_r=0.5).

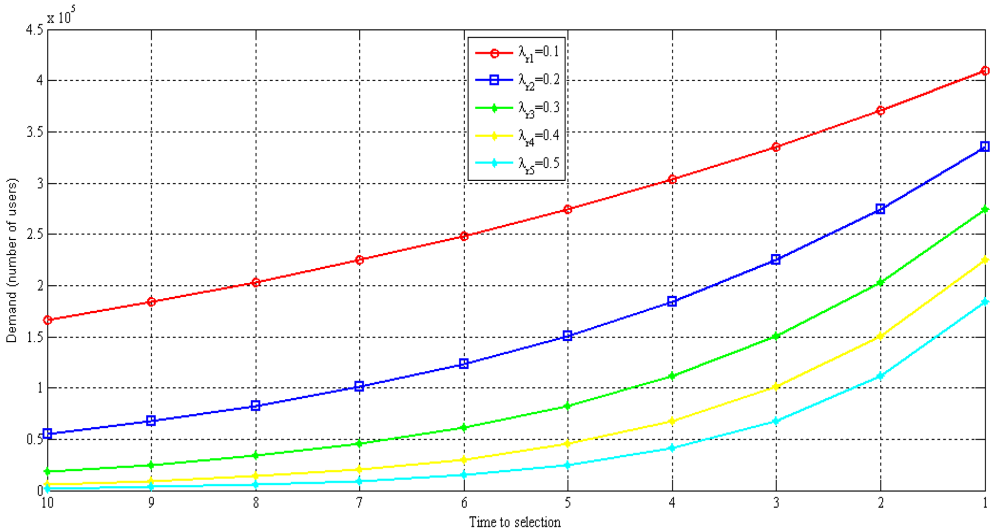

Figure 1. The demand function for different reputations

It could be seen that demand function greatly depends on SP`s credibility function. At initial time (t=10), SP with very low credibility (λ_r=0.5) has the lowest demand and it takes more time to better market position compared to SPs with higher credibility. A service announcement regarding the selecting date is more credible as the choosing date gets closer.

3.3 Price setting based on Nash Equilibrium concept

In this section, we focus on competition between two service providers competing for users by setting service prices. We consider what influence the price has on the demand function. To determine the trade-off between the price and credibility we propose the following SPi's profit function:

$$\Pi_i = D_i P_i - C_{si}, \quad i=1,2 \tag{5}$$

where:

D_i – total users' demand for the service SPi offers,
P_i – service price,
C_{si} – total SPi's cost of providing a service.

We assume that the total costs of providing a service are the same for all SPi ($C_{si} = C_s$). We consider here the competition between two service providers offering the same service in NGN market. In this case, total users' demand for some SP's service depends not only on its service price and reputation parameter, but on the other SPs` service price too, i.e.:

$$D_i = \left(1 - e^{-P_i^A P_j^B}\right) \cdot e^{-\lambda_{ri} \cdot t} \cdot m \tag{6}$$

where:
P_i, P_j – service prices the SPi and SPj offers, respectively,
A – users' sensitivity to the SPi service price variation,
B – users' sensitivity to the SPj service price variation,

In the previous formulation of total users' demand (Eq. 6) both A and B are defined as QoE parameters. Accordingly, profit functions of two competitive SPs can be expressed as follows:

$$\Pi_1 = \left(1 - e^{-P_1^A P_2^B}\right) \cdot e^{-\lambda_{r1} \cdot t} \cdot m \cdot P_1 - C_s \tag{7}$$

$$\Pi_2 = \left(1 - e^{-P_2^A P_1^B}\right) \cdot e^{-\lambda_{r2} \cdot t} \cdot m \cdot P_2 - C_s \tag{8}$$

This problem can be modelled as a simultaneous-play game between SPs in which all of them aim to maximize their corresponding objective functions, i.e. profits. The solution of this competition can be achieved as Nash equilibrium.

The best response of the SP_1 can be obtained from the optimal price P^* for which profit $\Pi_1(P_1^*,P_2)$ is maximized, given the price P_2 offered by the SP_2. Similarly, the best response of the SP_2 is the optimal price P_2^* for which profit $\Pi_2(P_1,P_2^*)$ is maximized given the price P_1 offered by the SP_1. This best response is denoted by $B_k(P_p) = arg\ max_{P_k}\ T_k(P_k, P_p)$, where P_p is the price offered by the other SP. Nash equilibrium gives the set of prices such that none of the service providers can increase the revenue by choosing a different price, with the given price offered by the other service provider. This is the point where $B_1(P_2^*) = P_1^*$ and $B_2(P_1^*) = P_2^*$.

4. EXPERIMENTAL RESULTS

Here, we analyze the broadband market in Serbia where two IPTV SPs exist: SP_1 who is offering IPTV service for more than two years and SP_2 who is just entering the market with IPTV service offer. Hence, we assumed that SP_1 has greater credibility compared to SP_2 and its reputation parameter is estimated to be λ_{r1}=0.1. Estimated reputation parameter for SP_2, as a new provider in NGN market is λ_{r2}=0.3. For both providers we assumed the following parameter values: A=-3.5, B=3.5, m=500.000, C_s=1000. Further assumption is P_1+P_2=3. SPs profit functions, as the output results, with the appropriate Nash equilibrium points at discrete times: t=10, t=5 and t=1 are given in Figures 2-4, respectively.

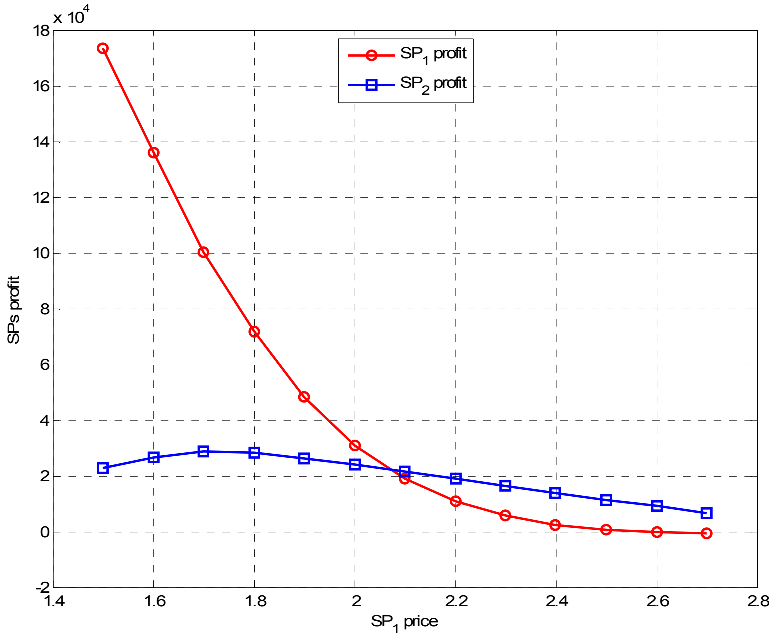

Figure 2. SPs profit functions and Nash equilibrium prices at *t*=10

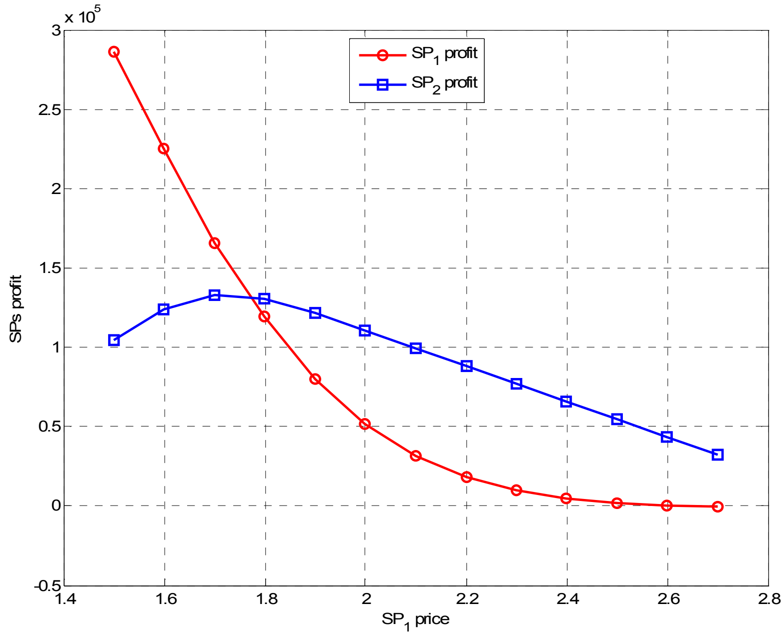

Figure 3. SPs profit functions and Nash equilibrium prices at *t*=5

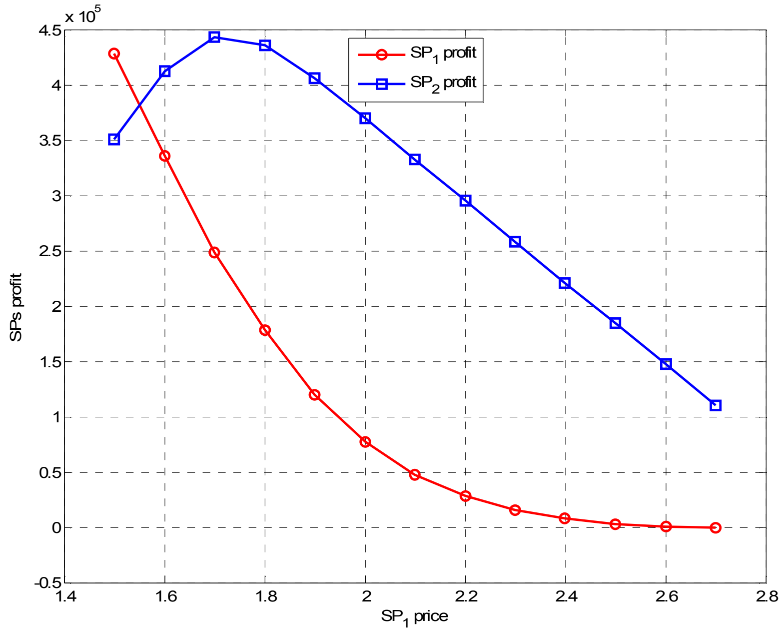

Figure 4. SPs profit functions and Nash equilibrium prices at *t*=1

The output results suggest that the service provider with lower credibility, i.e. SP_2 should charge less its users for the same service comparing to the provider with higher credibility, i.e. SP_1. At t=10, Nash equilibrium prices are P_1=2.06 and

P_2=0.94 for SP_1 and SP_2, respectively (Figure 2). As the time remaining to SP selection gets shorter, prices differences tend to be reduced. At t=5, Nash equilibrium prices are P_1=1.77 and P_2=1.23 (Figure 3) and at t=1, those prices are P_1=1.55 and P_2=1.45 (Figure 4). For each discrete time the model computes the providers' profits and calculates a Nash equilibrium based on market shares and content levels attained in the previous period as well as prices set in the current period. Although a theoretic equilibrium exists, there will always be fluctuations, and it is possible to characterize the conditions under which oscillations can be avoided or converge towards the equilibrium (Herbig, 1994).

6. CONCLUSIONS

Service providers are striving to differentiate themselves within expanding competitive NGN market by searching for ways to offer variety of services, achieve operational cost reductions and strategically position themselves in relation to their competition. In this paper we proposed a new pricing model which considers economic interactions of two competitive service providers offering the same service. The model includes demand function based on SP's reputation and service price. Economic theory indicates that there is a balance between the cost of establishing a good reputation and the financial benefit of having a good reputation, leading to equilibrium. We used Nash equilibrium concept for finding best strategy for both players in the game. It gives a practical and useful tool for analyzing the providers' behaviour in a competitive market depending on its pricing strategy. The main advantage of this model is its capability to determine appropriate SP's service price in respect to the competitive SP's service price. Also, this model can be useful for determining the trade-off between the price and reputation for long-standing and a new SP in the market. It gives possibility for a new SP to optimize its profit by offering lower price in order to compensate its weak reputation. In other words, the SP is able to obtain the best trade-off between its reputation and service price.

The obtained numerical results show that SP's reputation has great impact on its pricing policy, meaning that a provider with a good reputation has a significant advantage in market positioning. This model gives the possibility to analyze all possible situations that could happen in the market in advance and thus reducing the business risk. In future research we intend to expand the model by introducing several QoE parameters which will facilitate analysis of competition between providers offering QoS differentiation.

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