Content and Service Provider Interconnection Charging based on Revenue-Sharing Concept

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Abstract – **In this paper the application of Revenue-Sharing concept for provider's interconnection is analysed. Two types of contracts are shown, static and dynamic. The goal of our research is to consider possible market share enlargement according to price reduction. Relevant parameters in this research are provider's reputation factor and customer's willingness-to-pay.**

Keywords – ***Revenue-Sharing, contract, price sensitivity, reputation factor***

I. Introduction

The primary aim of Internet was to enable communication between remote hosts. Broadband access development transformed allows customers to connect with all available content (e.g. customers search information over Google, watch videos on YouTube etc.) [1]. Content provisioning involves many technologies, such as Content Delivery Networks (CDNs) and peer-to-peer networks; and different undertaking, such as Service Providers (SPs) and Content Providers (CPs). CP handles the distribution of online content including blogs, videos, music or files. In order to obtain connectivity and possibility for customers to purchase specific content from Content Providers, interconnection between Service Providers and Content Providers is necessary. Selection of proper charging strategy in such interconnection agreement is of great importance for providers. Improvement of market position and gathering enhanced revenues are often conflicted goals of providers' business strategy requiring compromises. Hence, providers negotiate in order to achieve satisfactory solution for involved parties. Although Cost-Based concept is widely recommended as the most appropriate charging concept, its complexity introduces the necessity for new, more feasible solutions. Revenue-Sharing concept is one of the alternative charging concepts, characterized with operational simplicity and possibility of rebalancing the returns of the providers when retail prices are distorted. In this paper, we address interconnection between Content Providers and Service Providers through Revenue-Sharing concept with the aim to improve providers' market position in long term by increasing customers' willingness-to-pay and their incentives to obtain specific content.

The paper is organized as follows. After introductory remarks, a brief literature review is given in Section II. Section III presents problem statement where two approaches of Revenue-Sharing concept are introduced. Revenues of content and service providers are observed considering content popularity, customers' willingness-to-pay and providers' reputation factor. Numerical example is presented in Section IV. Concluding remarks are presented in Section V.

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II. Literature Review

Determination of optimal Revenue-Sharing contracts between peering providers is presented in [2], for both symmetric and asymmetric retail prices. Relations among Internet Service Providers under network neutrality debate according to Revenue-Sharing peering and transit agreements are observed in [3]. Possibility of reorganization of revenue flows through an invoicing process that may benefit the mobile network operator more than the other involved parties is considered in [4]. Revenue-Sharing interconnection charging based on Service Level Agreement is observed in [5]. Game theory, especially Stackelberg setting, is employed addressing hierarchical decision structure. Amazon Internet portal has been investigating in that purposes in [6]. Non-cooperative and cooperative revenue sharing policies have been addressed in [7]. Non-cooperative policy might lead to unfair distribution of revenues among the providers. However, a charging strategy based on the weighted proportional fairness criterion stimulates cooperation among providers and can achieve higher profits for all involved providers. The effectiveness of Revenue-Sharing over other arrangements such as wholesale price contracts is observed in [8]. Revenue-Sharing as a charging strategy is widely investigated for supply chain coordination. Two-stage telecommunication supply chain under technology dependent stochastic demand has been analysed in [9], where Revenue-Sharing concept has been suggested.

III. Problem Statement

Let us consider full interconnection between several CPs and several SPs as shown on Fig. 1. Denote a set of CPs as $M=\{CP_1,CP_2,...,CP_m\}$, a set of SPs as $N=\{SP_1,SP_2,...,SP_n\}$, and a set of contents offered by all CPs as $Q=\{q_1,q_2,...,q_s\}$. We assume each CP is connected with all SPs. They offer a subset of contents Q_i such that

$$\bigcup_{i=1}^{m} Q_i \subseteq Q,\ Q_i \cap Q_j = \varnothing, \forall (i,j) \in (1,...,m), i \neq j \qquad (1)$$

For each content $q_k \in Q$ we define popularity factor,

$$\Psi_{q_k} = \frac{\lambda_{q_k}}{\sum_{k=1}^{s} \lambda_{q_k}}, \Psi_{q_k} \in (0,1) \quad (2)$$

where λ_{q_k} presents estimated number of requests for content q_k. Total number of estimated requests for all contents is expressed as $\sum_{k=1}^{s} \lambda_{q_k}$.

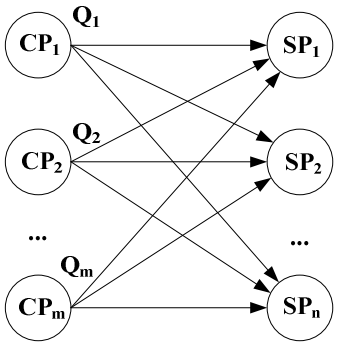

Fig. 1. Content and Service Provider Interconnection

In order to obtain appropriate Revenue-Sharing contracts between Content and Service Providers, such that provide market stability and ensure customers protection by reducing incentives of SPs to increase their retail prices, we analyse two types of contracts, static and dynamic. Static Revenue-Sharing concept defines fixed, predetermined, share of revenue that SPs obtain from provisioning CP's content on retail market. The aim of dynamic Revenue-Sharing contract is to stimulate providers to improve their market share, to strengthen market position and thus increase their revenue, rather than by price enhancement. Assume that total customer population, denoted as *X*, is fixed during observed time interval. Relevant parameters in these contracts are customers' willingness-to-pay specific content $q_k \in Q$ by the SP$_j$' retail price, $p_j^{q_k}$, and SPs' reputation factor. Customers' willingness-to-pay refers to the share of customers ready to pay given service/content by the retail price $p_j^{q_k}$. Regarding to the price sensitivity, two types of customers can be distinguished, more and less price sensitive. Thus, customers' willingness-to-pay mathematically can be expressed as follows:

$$W_j^{q_k} = \begin{cases} \dfrac{\alpha - \beta\left(p_j^{q_k}\right)}{N_{q_k}}, & \textit{for more sensitive customers} \\ \dfrac{\rho\left(p_j^{q_k}\right)^{-\varphi}}{N_{q_k}}, & \textit{for less sensitive customers} \end{cases} \quad (3)$$

Parameters in equation (3), α, β, ρ and φ depend on customers' social and economic status and content substitutability and popularity, as well. Willingness-to-pay is inversely proportional to the total number of SPs that offer content q_k at the market, denoted as N_{q_k}.

Content price reduction leads to enhancement of customers' willingness-to-pay for both types of customers. As a result, number of SPs' customers will increase. Thus, one of the most important providers' business goals, improved market share, will be satisfied. Another important parameter in proposed models is SPs' reputation factor. SP$_j$'s reputation factor is denoted by $r_j, r_j \in (0,1)$. This value is established on the basis of long term business existence of SP$_j$ on the market, and $\sum_{j=1}^{n} r_j = 1$. This means that value for SP's reputation factor is normalized and sum of the values for all SPs equals 1. We assume that reputation factor of all SPs on the observed market is known. Higher reputation factor is reason why a number of customers are willing to pay higher price for a specific content. We assume that Quality of Service (QoS) requirements are satisfied by all SPs. Revenue of SP$_j$ from provisioning content to the customers and CP$_i$'s revenue in accordance with the static revenue sharing contract can be, respectively, written as follows:

$$R_j^S = \sum_{i=1}^{m} \sum_{q_k \in Q_i} \left(1 - \Phi_{i,j}^{S,q_k}\right)\left(p_j^{q_k} \Psi_{q_k} r_j W_j^{q_k} X\right) \quad (4)$$

$$R_i^S = \sum_{j=1}^{n} \sum_{q_k \in Q_i} \Phi_{i,j}^{S,q_k} p_j^{q_k} \Psi_{q_k} r_j W_j^{q_k} X \quad (5)$$

$\Phi_{i,j}^{S,q_k}, \Phi_{i,j}^{S,q_k} \in (0,1)$ presents fixed portion of generated revenue that SP$_j$, by the contract, pays to CP$_i$ for provisioning content q_k under static Revenue-Sharing contract.

Dynamic Revenue-Sharing contract defines flexible portion of revenue that SP pays to the CP, depending on SP's retail price. SP$_j$'s revenue share paid to CP$_i$ under dynamic revenue sharing contract can be expressed as follows:

$$\Phi_{i,j}^{D,q_k} = \left(1 + \Delta p_j^{q_k}\right) \cdot \Phi_{i,j}^{S,q_k} \quad (6)$$

In equation (4), $\Delta p_j^{q_k}$ presents variation of SP$_j$'s retail price $p_j^{q_k}$. Thus, revenue of SP$_j$'s from provisioning content to the customers and CP$_i$'s revenue under dynamic Revenue-Sharing contract can be, respectively, written as follows:

$$R_j^D = \sum_{i=1}^{m} \sum_{q_k \in Q_i} \left(1 - \Phi_{i,j}^{D,q_k}\right)\left(p_j^{q_k} \Psi_{q_k} r_j W_j^{q_k} X\right) \quad (7)$$

$$R_i^D = \sum_{j=1}^{n} \sum_{q_k \in Q_i} \Phi_{i,j}^{D,q_k} p_j^{q_k} \Psi_{q_k} r_j W_j^{q_k} X \quad (8)$$

IV. Numerical Example

Let us consider the situation in when Revenue-Sharing concept is applied as a relevant interconnection agreement between CP and SPs. There are two CPs and two SPs at the market. Each CP offers single content differentiated from the one offered by other CP. Providers negotiate in order to

determine revenue share on the Revenue-Sharing basis. We assume that one SP is a new entrant at the observed market. It has having lower reputation factor compared to the other SP. Regarding to the customers' price sensitivity, two scenarios are assumed. The first scenario refers to the situation when only one SP increases retail price for more popular content and services related to that content, while other SP remains its price for the same content at the same level. The second scenario considers price reduction by the SP_1, offering higher price for less popular content. This situation is common when promotions and discounts are being applied. Values for parameters in the relation for customers' willingness-to-pay are specified according to assumed market situation. We assumed that values of relevant factors for calculation of revenues are the following: $X = 200000$, $\Phi_{i,j}^{S,q_k} = \Phi^S = 0.5$, $p_1^{q_1} = 100$, $p_1^{q_2} = 110$, $p_2^{q_1} = 90$, $p_2^{q_2} = 100$, $r_1 = 0.65$, $r_2 = 0.35$, $\Psi_{q_1} = 0.3$, $\Psi_{q_2} = 0.7$. All obtained revenues are expressed in monetary units [MU].

Fig. 2. presents revenue of SP_2 obtained applying static and dynamic Revenue-Sharing concepts for more price sensitive customers. Revenue of SP_2 obtained applying static and dynamic Revenue-Sharing concepts for less price sensitive customers is shown on Fig. 3.

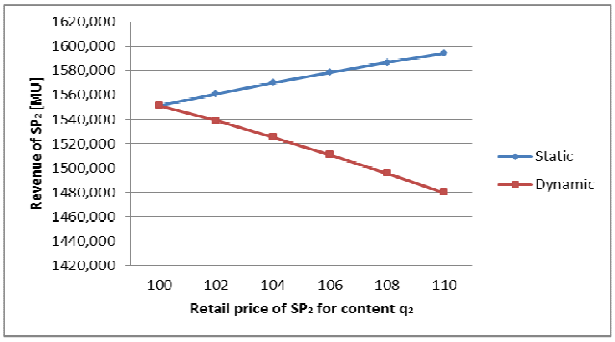

Fig. 2. Revenue of SP_2 under static and dynamic Revenue-Sharing concept for more price sensitive customers

Static Revenue-Sharing concept increases SP_2 revenue when retail price for more popular content increases, while dynamic reduces for both more and less price sensitive customers, as shown on Fig. 3. Considering dynamic revenue sharing contract, SP_2 has no incentive to increase its retail price. It can be noted that revenue approximately remains at the same level for less price sensitive customers for both more and less price sensitive customers.

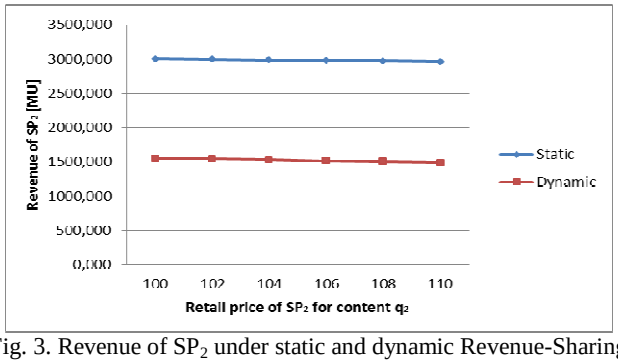

Fig. 3. Revenue of SP_2 under static and dynamic Revenue-Sharing concept for less price sensitive customers

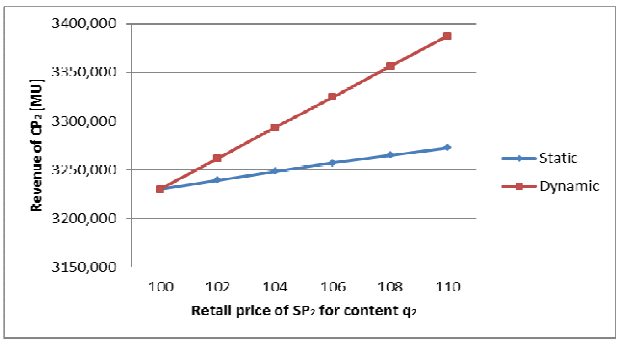

Fig. 4. Revenue of CP2 under static and dynamic Revenue-Sharing concept for more price sensitive customers

Fig. 4. presents revenue of CP_2 offering more popular content q_2, when SP_2 increases its retail price for that content, for more price sensitive customers. Obtained results for less price sensitive customers are shown in Fig. 5.

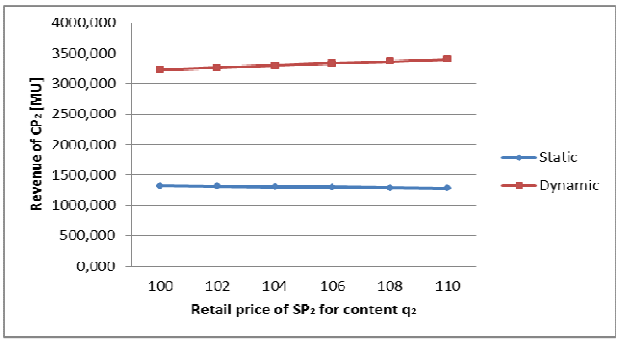

Fig. 5. Revenue of CP2 under static and dynamic Revenue-Sharing concept for less price sensitive customers

For more price sensitive customers, dynamic revenue sharing contract enhance CP_2's revenue. However, for less price sensitive customers, revenue is nearly at the same level, but high above revenue under static Revenue-Sharing concept.

Situation when retail price for less popular content, q_1, decreases in order to attracts more customers according to static and dynamic Revenue-Sharing concept for more price sensitive customers is shown on Fig. 6. SP_1 decreases its retail price for content q_1 by the level of SP_2's retail price. Since content q_1 is less popular, SP_1 is looking for appropriate concept that will increase customers' interest for that content, but to increase its revenue, as well. Dynamic Revenue-

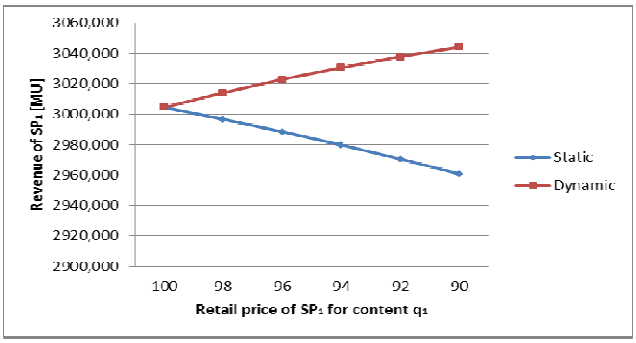

Fig. 6. Revenue of SP1 under static and dynamic Revenue-Sharing concept for more price sensitive customers

Sharing concept increases SP_1's incentives to decrease retail price for less popular content q_1, thus enhancing its revenue.

Fig. 7. depicts situation when SP1 decreases retail price for less popular content, q_1, for less price sensitive customers. Obtained results are nearly the same as for more price sensitive customers.

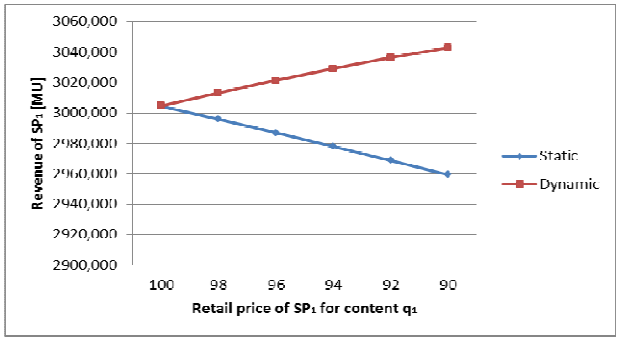

Fig. 7. Revenue of SP1 under static and dynamic Revenue-Sharing concept for less price sensitive customers

Revenue of CP_1, offering less popular content, when SP_1 decreases its retail price for content q_1 is shown on Fig. 8. Both static and dynamic Revenue-Sharing concepts decrease revenue of CP_1. Regarding static concept, revenue slowly decays in comparison with dynamic.

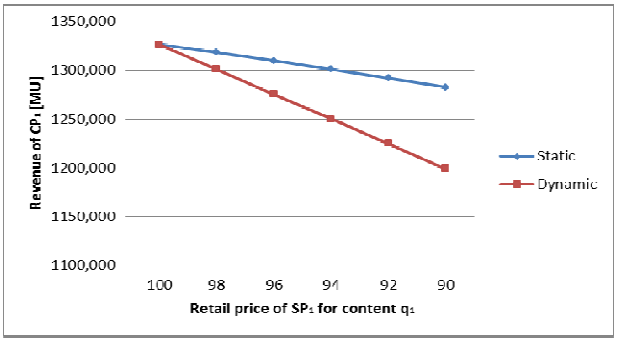

Fig. 8. Revenue of SP1 under static and dynamic Revenue-Sharing concept for more price sensitive customers

Fig. 9. shows revenue of CP_1 when SP1 decreases its retail price for less popular content, in the case of less price sensitive customers. Retail prices enhancement ensures greater revenue for CP. However, it leads to reduction of customers' willingness-to-pay and reduction of market share in long term.

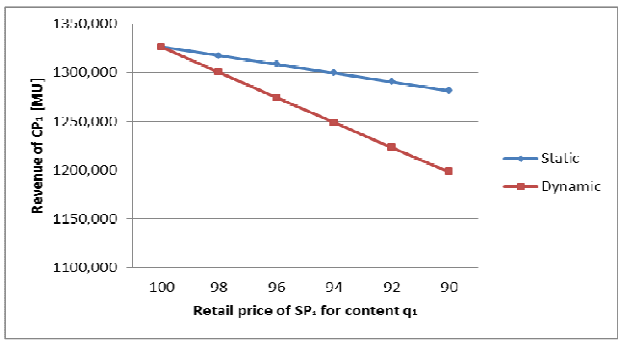

Fig. 9. Revenue of SP_1 under static and dynamic Revenue-Sharing concept for less price sensitive customers

V. Conclusion

This paper analyses possibility of application of Revenue-Sharing concept for charging interconnection between Content Providers and Service Providers on the given market. Two types of this concept are observed, static and dynamic. Static Revenue-Sharing concept establishes fixed portion of revenue that Service Provider pays to Content Provider. Dynamic Revenue-Sharing concept depends on retail price and involves fixed portion of revenue that SP pays to CP, but involves variable part which reflects retail price variation. Depending on service and hence, on content popularity, providers' reputation factor and customers' willingness-to-pay, revenues of specific provider are being analysed. The aim of dynamic revenue sharing contract is to enlarge customer base by price reduction, and thus improve providers' market position. It was shown that proposed dynamic Revenue-Sharing concept enables great incentives to reduce retail prices and increase revenue on the improved market share rather than price enhancement.

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