

Vertical Integration Between Providers With Possible Cloud Migration

Aleksandra Kostic-Ljubisavljevic

University of Belgrade, Serbia

Branka Mikavica

University of Belgrade, Serbia

INTRODUCTION

The continuous growth of Internet traffic is significantly pushed by emerging high bandwidth demanding contents. All participants in content provisioning process including content providers, service providers, Content Delivery Networks (CDN) and customers are influenced by bandwidth requirements. Appropriate bandwidth demand estimation and consequently, network dimensioning are of great importance for addressing resource investment. However, peak bandwidth demand varies during the day. Provisioning of self-owned resources that satisfy peak bandwidth demand leads to network underutilization in the periods of low or normal traffic load. Hence, over-provisioning is cost ineffective. On the other hand, under-provisioning of network resources leads to rejection of customers' requests for service provisioning. Considering all aforementioned, vertically integrated providers in content provisioning process need to consider cloud migration in order to minimize costs and improve Quality of Service (QoS) and hence Quality of Experience (QoE) of their customers. Cloud providers maintain large-scale data centres to offer storage and computational resources in the form of Virtual Machines instances at a relatively low cost. Depending on the characteristics, cloud instances are available at different prices. In general, cloud providers offer three different pricing plans, such as reservation, on-demand and spot pricing. With the aim of obtaining

optimal integration charging strategy, concepts like Revenue Sharing, Cost Sharing, Wholesale Price etc. are applied frequently. Involvement of cloud providers into content provisioning process introduces additional complexity for choosing appropriate interconnection contract. The vertically integrated content provider's incentives for cloud migration can induce significant changes in integration contracts, and consequently in costs and requests' rejection rate.

In this chapter different methods of vertical integration charging among providers are analyzed and compared. With the aim of QoS and QoE improvement, providers can perform cloud migration. In that manner, cloud resources utilization concepts like reservation, on demand, and potential application of spot-pricing are going to be analyzed.

BACKGROUND

In order to provide content to the customers, vertical integration between providers is necessary. Term vertical integration refers to interconnection, i.e. physical and logical connecting, among providers operating at different network's levels. For instance, long-distance operator and local operator can be vertically integrated. Intrinsically, interconnection enables customers connected to one network to communicate with customers of the same or different network. It is a set of legal rules, technical and operational arrangements

which providers use to connect their equipment, networks and services. Vertical integration is economical, efficient and it enables achievement of economies of scale (Dai & Tang, 2009). Often applied contracts are Revenue Sharing, Cost Sharing and Wholesale Price. Instead of explicitly defined interconnection tariffs, operators often apply Revenue Sharing, which establishes fixed revenue share among providers. This type of contract is characterized with operational simplicity, and it can rebalance providers' returns when retail prices are distorted for any reason. Some of the greatest challenges that providers are dealing with are increasing profitability of the offered services, assuring higher charges for improved services and obtaining a fair share of the increased revenues. A fair Revenue Sharing contract based on the weighed proportional fairness criterion is proposed by He & Warland, (2006). They also show that non-cooperative strategies between providers may lead to unfair distribution of profit and may even discourage future upgrades to the network. Modelling of non-cooperative interaction between service providers and content provider as a Stackelberg game is performed by Wu, Kim, Hande, Chiang & Tsang (2011). These authors propose Revenue Sharing contract between service providers that jointly provide network connectivity between content provider and customers. They introduce profit division factor into the contract with the aim of social profit's maximization. Revenue Sharing contract between content provider and two service providers under network neutrality debate is observed by Coucheney, Maille, & Tuffin (2014). In this model, service providers enable direct connectivity to a fixed proportion of the content and compete in terms of price for customers. Relations between service providers are established using Revenue Sharing contract in order to maximize customers' welfare.

Revenue Sharing and Cost Sharing contracts are often formulated using Shapley value (Lee, Jang, Yi & Cho, 2013; Bogomolnaia, Holzman & Moulin, 2010). This mathematical method allocates resources according to contributions

of each party in a fair manner. Application of Shapley value in order to obtain a proper revenue distribution between content and service provider with elastic and inelastic demand is proposed by Ma, Chiu, Lui, Misra & Rubenstein (2008). The following formulations of Cost Sharing contract in backbone networks: volume-device, 95th percentile-device, 95th percentile-customer, customer peak-device, aggregate peak-device and Shapley-device, are analyzed and compared by Gyarmati, Sirivianos, & Laoutaris, (2012). The results show that Shapley-device contract better reflects the costs of the customers and improves fairness compared to other observed contracts. Key characteristic of Cost Sharing contract is enabling a compensation for the costs that provider incurs in carrying traffic generated by other providers.

Under Wholesale Price contract, service provider's payment to content provider for content provisioning depends on the established wholesale unit price and the traffic volume. The process of determining wholesale prices for mobile virtual networks operators and relations among vertically integrated incumbents when downstream entries are present under Wholesale Price contract are described by Song (2010). It appears that wholesale price can be the lower limit of the retail price, and determines the competitiveness of mobile virtual networks operators. Related regulatory issues have also been considered and it emphasizes the fact that regulators should have long-term perspective for the market.

In order to improve content provisioning process and assure satisfactory QoS and QoE, bandwidth demand estimation is essential. Content requires a certain minimal bandwidth which assures that customers' experience in content provisioning is satisfactory. Also, content has assigned content popularity factor, addressing the probability of access to certain content. In bandwidth demand estimation, parameter depicting content popularity is an important parameter and has to be included in network dimensioning process. Contents' differentiation according to its assigned popularity is of great importance for load

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