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Pricing, Competition and Content for Internet Service Providers

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Abstract:

We examine competition between two Internet Service Providers (ISPs), where the first ISP provides basic Internet service, while the second ISP provides Internet service plus content, i.e., *enhanced service*, where the first ISP can partner with a Content Provider to provide the same content as the second ISP. When such a partnering arrangement occurs, the Content Provider pays the first ISP a transfer price for delivering the content. Users have heterogeneous preferences, and each in general faces three options: (1) buy basic Internet service from the first ISP; (2) buy enhanced service from the second ISP; or (3) buy enhanced service jointly from the first ISP and the Content Provider. We derive results on the existence and uniqueness of a Nash equilibrium, and provide closed-form expressions for the prices, user masses, and profits of the two ISPs and the Content Provider. When the first ISP has the ability to choose the transfer price, then when congestion is linear in the load, it is never optimal for the first ISP to set a negative transfer price in the hope of attracting more revenue from additional customers desiring enhanced service. Conversely, when congestion is sufficiently super-linear, the optimal strategy for the first ISP is either to set a negative transfer price (subsidizing the Content Provider) or to set a high transfer price that shuts the Content Provider out of the market.

I. INTRODUCTION

Several years ago, Comcast complained to the FCC that Netflix was asking for special access to its broadband network. Comcast said that the issue could cause a financial dispute, but it did not require the involvement of regulators. Netflix's response to the FCC was that it was not seeking special treatment, and was being pressured by large operators having market power to pay for improved delivery of its content.In this paper we address questions of pricing and competition in a market where users connect to a service provider that either offers basic Internet service or enhanced service, i.e., Internet service plus content. This could be low bitrate stream content, such as audio and certain types of video, or high bit-rate stream content, such as high-definition television.

We characterize the enhanced service by the relative bandwidth, b, it requires as compared with basic service. If the relative bandwidth b=1, this means that the enhanced service takes essentially the same bandwidth as the basic service, i.e., the content requires negligible additional bandwidth; for example, when the service consists of streaming music over a well-provisioned fixed network. If the bandwidth b>1, this means that the enhanced service places an extra load on the network. In cases where the relative bandwidth b is large, this implies that the content requires high bandwidth compared to basic Internet usage; for example, delivering movies over the existing infrastructure.In our model we consider the existence of an ISP that offers basic Internet service (network 1) competing with a second ISP (network 2) that offers Internet service plus content. In addition, we assume the existence of a third-party Content Provider (CP) that offers the same content as is provided by network 2, and which can partner with network 1 to jointly provide the content to consumers, where network 1 charges the Content Provider a transfer price for delivering the content. We make no restrictions on the transfer price; in particular, it can be positive, negative—i.e., a subsidy, perhaps imposed by a regulator—or zero.

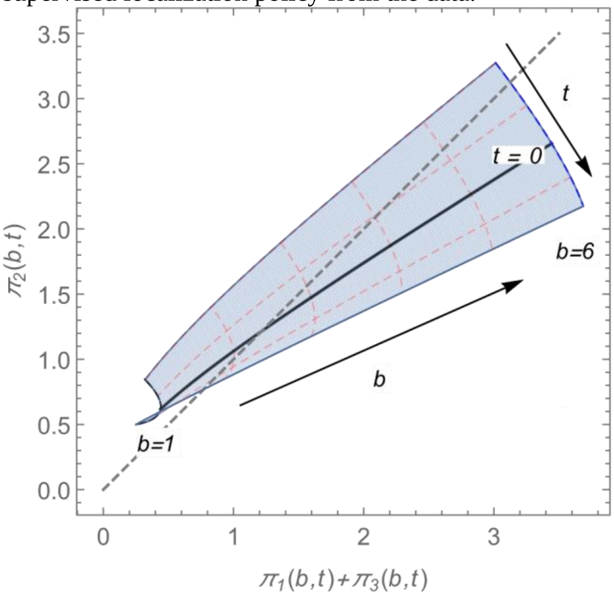
Users will generally differ in their willingness to pay, w, for content. Each user has, in general, three options: (Option 1) buy basic Internet service from network 1 at price p_1, (Option 2) buy enhanced service from network 2 at price p_2, or (Option 3) buy enhanced service jointly from network 1 and the Content Provider at price p_1+p_3. In choosing which network to join, a user takes into consideration not only the type of service and total price he would need to pay, but also the level of congestion on the network.

II. RELATED WORK

This paper is related to both the literature on charging schemes for congestible resources, and the literature on congestion games in communication networks. From the charging scheme literature, the most relevant paper to our work is de Palma and Leruth [4], which examined duopoly outcomes for two firms in a setting similar to our base model. However, [4] models two firms offering an identical service, in contrast to our model in which one firm offers a basic service and the other firm offers an enhanced service, but the first firm can offer the enhanced service by partnering with a third firm.The literature on congestion games in communication networks is large and growing rapidly. Marden and Wierman considered a game-theoretic approach to the study of utility design for distributed resource allocation. They introduced a class of games they refer to as “distributed welfare games,” and demonstrate that cost sharing methodologies are beneficial for utility design. Their work has a broad range of applications that includes communication networks.Gibbens *et al.*considered competition between two networks, each of which may offer multiple services classes generated by subdivision of the network into subnetworks, differentiated only by capacity, price, and the consequent level of congestion, i.e., “Paris Metro pricing.” Specifically, their model has two competing, profit-maximizing Internet Service Providers, each of which may offer either one or two service classes. In the case where an ISP chooses to offer two service classes, it forms them by logically dividing its network in two, and charging separate prices on each subnetwork. Congestion on a subnetwork is determined in equilibrium by the fraction of the first ISP’s total network capacity allocated to a subnetwork, and the number of users on the subnetwork. The main result is that, in the unique equilibrium outcome, neither ISP subdivides its network and the two firms charge the same price. These results tend to indicate that Paris Metro Pricing will not be viable in a competitive market.

III. PROPOSED WORK

Deep learning has proven to be successful in a multitude of computer vision tasks ranging from object recognition and detection to semantic segmentation. Motivated by these results more recently DL has been increasing use in medical applications, e.g. for bio-medical segmentation of image or detection of pneumonia from chest X-ray. These seminal works indicate that, with the availability of data, DL can lead to the assistance and automation of preliminary diagnosis which are of risky significance in the medical community. In the wake of the present pandemic, recent works have focused on the detection of COVID-19 from chest CT. In a u net type network is used to regress a bound box for each suspicious COVID-19 pneumonia region on consecutive CT scans, and a quadrant-based filtering is exploited to reduce possible false positive detections. Differently, in a threshold-based region proposal is first used to retrieve the region of interests in the input scan and the Inception network is exploited to classify each proposed. Similarly, during a VNET-IR-RPN model pre-trained for consumption detection is used to propose within the input CT and a 3D version of Resnet-18 is employed to classify. Very few works using DL on LUS image can be found in the nooks. A dividing and weakly supervised method localization for lung pathology is described. Based on the same thought, in a frame-based classification and weakly-supervised segmentation method is applied on LUS images for COVID-19 related pattern detection CAMs are used for localization and scan the reports, in this work we exploit STN to learn a weakly supervised localization policy from the data.



IV. METHODOLOGY

We model a setting where three firms compete to maximize individual profits: Network 1 provides basic service, network 2 provides enhanced service, and a Content Provider provides enhanced service over network 1. As discussed in [6], there is good reason to suppose that, under certain circumstances, industries with congestion may have very concentrated market structure; that is, there exist a small number of firms collectively having a large market share. (See for example Further, as Gibbens *et al.* point out, this setting is the most transparent environment in which to study the effect of competition on the use of multiple service classes.We assume that a user pays a price *per unit time* for the right to be connected to and receive service or services from network *i*. Thus, network prices are subscription-based. In [13], Cachon and Feldman consider the question, “How should a firm price its service when congestion is an unavoidable reality?” They point out that some firms sell subscriptions for their service, citing as an example the Internet Service Provider AOL. AOL initially charged customers per-use access fees, but later switched to subscription pricing in the form of a monthly fee with no usage limitation. The authors find that subscription pricing is more effective at earning revenue than per-use access fees. They conclude that subscription pricing can be effective even if congestion is relevant for the overall quality of the service.\

V. FUTURE ENHANCEMENT

The paper of Johari *et al.* [8] is complementary to ours, in that it considers the question of investment as well as price setting, and for homogeneous rather than heterogeneous users. We can deal with homogeneous users in our model by setting the continuous preference space w to a point mass, w_0, and carrying through our analysis for this degenerate case. However, the presence of the Content Provider, which has no capacity of its own, means that in general user masses will no longer be uniquely defined. Nevertheless, when there is no transfer price and where b = 1, our results carry over with the appropriate adjustments, and we can show that, analogous to Theorem 2, there exists a unique Nash equilibrium with networks 1 and 2 and the Content Provider each having users, provided that a simple condition is satisfied ($w_0\widehat{C}_1 \leq 1+2/r$).

VI. CONCLUSION

This paper considers an ISP providing basic Internet service (at price p_1) competing with an ISP that provides *enhanced service*, i.e., both Internet service and content (at price p_2), where the basic service ISP can partner with a Content Provider, who charges each user an additional price (p_3) for the content, where the Content Provider pays the basic service ISP a transfer price (t) for delivering the content. The transfer price can be positive, negative, or zero. A positive transfer price could be a termination fee reflecting discriminatory pricing by network 1 against the Content Provider; note that this would contravene the *zero-price rule* interpretation of net neutrality [9], [19]. Alternatively, the positive transfer price may be compensation paid to network 1 mandated by a regulator, or an agreed transfer price negotiated bilaterally between network 1 and the Content Provider.

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