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Optimizing direct response in Internet display advertising

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ABSTRACT

Internet display advertising has grown into a multi-billion dollar a year global industry and direct response campaigns account for about three-quarters of all Internet display advertising. In such campaigns, advertisers reach out to a target audience via some form of a visual advertisement (hereinafter also called "ad") to maximize short-term sales revenue. In this study, we formulate an advertiser's revenue maximization problem in direct response Internet display advertisement campaigns as a mixed integer program via piecewise linear approximation of the revenue function. A novelty of our approach is that ad location and content issues are explicitly incorporated in the optimization model. Computational experiments on a large-scale actual campaign indicate that adopting the optimal media schedule can significantly increase advertising revenues without any budget changes, and reasonably sized instances of the problem can be solved within short execution times.

1. Introduction

Since the first banner ad appeared on the Internet in 1994, Internet advertising has become a multi-billion dollar a year global industry; significantly surpassing radio advertisement and becoming the third largest market right behind TV and newspapers (Silverman 2010). The top two forms of Internet advertising are *paid-search* and *display advertising*. In paid-search advertising, advertisers pay an advertising fee, usually based on ad views or click-throughs, to have their websites shown in top placement on search engine result pages. In Internet display advertising (IDA), which is the subject of this study, advertisers reach out to a target Internet audience via some form of a visual advertisement such as display banner ads, flash-based rich media, or digital video. One study indicates that IDA has grown into a $17 billion global industry in 2009 (Soriano 2010), and another one reports that US. Internet users received a total of 4.9 trillion display ads in 2010 (Radwanick 2011).

Traditionally, objective of an IDA campaign is characterized as being either *branding* or *direct response*. Branding campaigns are long-term advertisement investments with goals such as boosting brand awareness, generating new customer lead, and improving customer relationship (Hollis 2005). In practice, branding campaigns aim to maximize the *reach* of the campaign, i.e., the proportion of the target audience exposed to at least one ad. In contrast, the goal in a direct response campaign is to achieve a measurable, direct, and immediate response. In general, direct response campaigns try to maximize revenue obtained by click-through or view-through conversions.

The objective of an IDA campaign depends on the specific business needs of the advertiser. Hollis (2005) suggests that the two paradigms, i.e., branding and direct response, are not contradictory but they are in fact complementary and that the applicability of either model depends not only on the intent of the advertiser but also the mindset of the audience. It can thus be argued that the two objectives are not mutually exclusive, yet, at a conceptual level, how the advertising budget should be prioritized is usually a matter of debate, and it is beyond the scope of this study. Nonetheless, direct response campaigns seem to be especially popular in the online arena. It is estimated that direct response advertising accounts for about 75% of all ad dollars spent online (Cox et al. 2010). One possible explanation is that technology allows for straightforward measurement of return on investment (ROI) in direct response IDA campaigns, whereas measuring ROI in branding campaigns is usually a long-term effort requiring elaborate experimental designs spanning across several weeks or months, or even years.

Despite its significant market share and vast popularity, currently there exists only one study in the literature on IDA optimization from an advertiser's perspective. Specifically, the work by Danaher et al. (2010) is the first of its kind on optimal Internet media selection where the authors model Internet media exposure via multivariate negative binomial distribution and use nonlinear programming to maximize reach in IDA campaigns. The methodology presented therein, however, has two limitations. First, it can only be used for selection of websites. Second, it can only be utilized in optimization of branding campaigns. The purpose of this

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study is therefore to develop a mathematical model for optimization of direct response IDA campaigns that explicitly incorporates ad location and content issues as well as click-through and conversion rates. We also illustrate the efficiency and ease-of-use of our methodology on a $285,000 actual advertising campaign.

The mathematical model presented in this study is for maximizing revenues of a single advertiser conducting a particular direct response Internet advertising campaign. That is, the optimization problem we consider is from an advertiser's point of view. It is important to distinguish this problem from that of Web publishers whose goal is to schedule and place ads from multiple advertisers to maximize *their* revenues.

The rest of this manuscript is organized as follows. Section 2 provides a literature review, and Section 3 presents our IDA model including terminology, notation, and several fundamental IDA concepts relevant to our discussion. Also included in this section is the definition of the optimization problem and its illustration using a sample campaign data. Section 4 describes our methodology in detail and presents a mathematical model for optimization of click-through conversions. Section 5 discusses view-through conversions and shows how our methodology can be adapted for tracking view-through conversions. Section 6 illustrates application of the optimization model on our sample data, and Section 7 presents summary and conclusions.

2. Literature review

There exists a vast amount of literature on various aspects of Internet advertising. A comprehensive review of previous research on this topic within the advertising community can be found in Ha (2008). Economical aspects of Internet advertising as well as its evolution over the past decade were discussed in Evans (2009). These studies considered both paid search and display advertising. Existing optimization-oriented research on display advertising can broadly be categorized into three groups: (1) ad scheduling and placement optimization, (2) revenue management and pricing optimization, and (3) studies on overall display advertising effectiveness. Previous research in these categories is briefly described below.

The problem of scheduling and placing ads on a website so as to maximize revenues of the Web publisher operating the website was studied in Adler et al. (2002), Menon and Amiri (2004), Nakamura and Abe (2005), and Kumar et al. (2006). The same problem was considered in Kumar et al. (2007) under a hybrid pricing scheme where ad price is a function of both the number of ad exposures and the number of clicks on the ad.

An overview of current pricing schemes in display advertising can be found in Dickinger and Zorn (2008). A comparison of pay-per-view and pay-per-click pricing—two of the most commonly used pricing schemes in the industry—was given in Mangani (2004). Kumar and Sethi (2009) proposed a dynamic pricing model based on optimal control theory whereas Moon and Kwon (2010) introduced a new hybrid pricing scheme using Nash bargaining theory. Revenue management models for display advertising were proposed in Roels and Fridgeirsdottir (2009) and Karmarkar and Dutta (2010). Balseiro et al. (2011) investigated revenue management issues in the presence of ad exchanges, which is an emerging market for real-time sale of online ad inventory on the Internet. Studies on ad scheduling and placement as well as on revenue management and pricing were almost exclusively conducted from Web publishers' perspective.

Regarding display advertising effectiveness, Hollis (2005) discussed branding vs. direct response in display advertising and Manchanda et al. (2006) studied effects of banner ads on purchasing patterns. Impacts of content and design elements on click-through rates for banner ads were studied in Lohtia et al. (2003) and Robinson et al. (2007) whereas effects of ad exposure time were investigated in Goldstein et al. (2011). On the other hand, ad exposure distribution models based on the multivariate negative binomial distribution were presented in Huang and Lin (2006) and Danaher (2007).

The work of Danaher et al. (2010) seems to be the only study in the literature that considers the ad allocation problem from an advertiser's point of view. In this study, the authors presented a nonlinear model for maximization of reach in display advertising campaigns. Therefore, it can only be used in optimization of branding campaigns. In addition, the authors considered only selection of websites. The subject of our study, which is maximization of direct response revenue, differs considerably from that of Danaher et al. (2010) as our work explicitly incorporates ad placement and content issues, and also accounts for differences in click-through rates across different number of exposures in a non-trivial way. Besides, the methodology presented therein cannot be used for selection of more than a dozen or so websites due to the model's nonlinear nature, whereas the methodology presented in this work can be utilized for optimization of hundreds of ad combinations as it is based on piecewise linear approximation of nonlinear ad revenue functions.

3. A model for Internet display advertising

3.1. Terminology

An *advertiser* is an entity (a company, government agency, educational institution, etc.) conducting an advertisement campaign for one or more of its products or services. Typically, an advertisement campaign is conducted over multiple channels such as TV, radio, newspapers, billboards, magazines, the Internet, etc. Our focus in this work is on the Internet channel. In this regard, we define a *publisher* as the operator of one or more websites on which the advertiser's ads are displayed.

Formally, a *website* can be defined as a collection of related Web pages that are addressed by a common Internet domain name. In practice, a website's main page and its subsections may be defined as separate websites. For example, `cnn.com` main page and its finance section, `money.cnn.com`, may be considered as two different websites depending on the advertiser's specific business needs.

A *click-through* is defined as a user-initiated action of clicking on an ad that typically results in a redirection to the advertiser's website. Revenue-generating user actions such as making a purchase or subscribing to a service are called *conversions*. A conversion is sometimes called an *acquisition*.

In general, direct response Internet advertisers track two types of conversions: *click-through* and *view-through conversions* (Bruner and Gluck 2006). In click-through conversions, the conversion takes place immediately after the click-through. In view-through conversions, the conversion takes place within a specific time frame after the user has been exposed to at least one ad.

The ratio of the number of times an ad is clicked to the number of ads shown is called the *click-through rate* (CTR). The ratio of the number of conversions to the number of ad clicks is called the *conversion rate* (CVR). It should be noted that the denominator in CVR is the number of ad clicks and not the number of impressions.

An *impression* is the publisher-initiated action of loading an ad into the Web browser for the user's view when the user visits the publisher's website. An *exposure*, on the other hand, occurs when the user actually views the ad. Explicit exposure data is usually unavailable (Danaher 2007), so we treat the two concepts equivalently.