

Survey Paper on Stochastic Modeling and Optimization for Online Advertisements

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Abstract—In this paper, we propose a stochastic modeling and optimization for online advertisements, this stochastic modeling is to describe how search service providers charge client companies for posting their ads based on users' queries for the keywords related to these companies' ads by using certain advertisement assignment strategies. A stochastic model is non-deterministic model. We also formulate an optimization problem for stochastic modeling to maximize the long-term average revenue for the service provider under each client's long-term average budget constraint and design an online algorithm which captures the stochastic properties of users' queries and click-through behaviors. Optimization problem arises here, so that to solving this optimization problem by making connections to scheduling problems in wireless networks, queuing theory and the stochastic networks. With a view towards practice, we can show that one can always operate strictly under the budget. In addition, we extend our results to a click-through rate maximization model and also show how our algorithm can be modified to handle non-stationary query arrival processes and clients with short-term contracts. However, most of the advertising programs on the Web have not fully taken the advantages of the Web's interactive capabilities. Then, we also propose architecture of web-based brand advertising platform based on a proposition that interactive advertising has to satisfy advertisers' marketing objectives as well as consumers' requirements.

Index Terms— online advertising, optimization, stochastic systems, bidding.

I. INTRODUCTION

Today's world is the Internet World, due to this surprising growth of the Internet has been increased day by day, so due to this surprising growth of the Internet population, the World Wide Web has become a fantastic marketing channel. Among marketing activities, advertising might be one of the most popular activities and the one that can take the most advantages of specialties of the Web.

Advertising is the form of marketing communication and it is useful for encourage or manipulate audience such as listeners, readers, and viewers. The advantage of web advertising includes low cost, multimedia, interaction, easy maintenance, round-the-clock and worldwide presentation and almost unlimited advertising space, etc. Besides, Web advertising has ability of combing advertising and purchase behavior through the Internet.

An online advertising service has been the major source of revenue for search service providers such as Google, Yahoo and Microsoft. When an Internet user queries a keyword, alongside the search results, the search engine may also display advertisements from some companies which provide services or goods based on the keyword related to this client companies. These companies pay the search service providers for posting their ads with a specified amount of price for each ad on a pay-per impression or pay-per-click basis [1].



Fig. 1: Time line of the two-stage game-theoretical model.

A system for providing advertisements has been the major source of revenue for search service providers from a central server to viewers who access web sites. The central server stores both advertisements which are to be displayed and an information data base. The data base includes information about viewers included in audience, information about the characteristics of particular web sites and other information relevant to which advertisements should be displayed for particular viewers.

II. AN ARCHITECTURE OF A WEB-BASED BRAND ADVERTISING PLATFORM

There is a large number of web-based Advertising Networks competing for advertising dollar. Many publishers and advertisers rely on user's behavioral or contextual data to target consumers online. Web-Based brands are promoted to audience through the web according to their demographic characteristics. This approach requires a platform that can infer or predict the actual demographic segmentation using user's behavior collected across a diverse set of web sites.

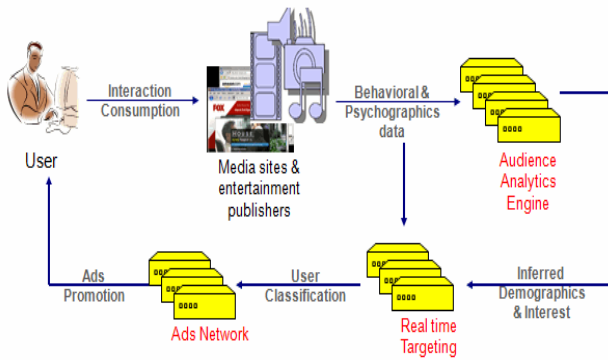


Fig.2: Architecture of a web-based brand advertising platform

We propose architecture of a web-based brand advertising platform Figure 2. In this figure we see Audience analytics engine, Real time targeting and Ads network. This is useful for interaction with the user.

The basic requirements of an online audience analytics and targeting solution are:

- To collect user behavior across multiple web sites
- To organize and index information regarding users behavior and the content they consume
- To infer demographics and interest data
- To classify new user in real time
- To match demographics and content with ads inventory
- To deliver advertising in the appropriate format and in timely fashion.

III. KEYWORD OPTIMIZATION IN SEARCH BASED ADVERTISING

Keyword optimization for search based advertising has been the focus of some theoretical and applicative work. Rusmevichientong and Williamson [12] have formulated a model for keyword selection in search based advertising. In their model, the advertiser has a fixed daily budget and each keyword has fixed known cost and profit. However, the keyword click-through probabilities are unknown. The numbers of queries appearing in each of the days, as well as the distribution of keywords, are generated probabilistically with known parameters. They justify their assumptions about keyword costs and distribution by identifying multiple public available data sources that may be used to estimate these parameters. The three stochastic models discussed in [13] are:

1. Fixed proportions model

In fixed proportions model only random variable is the total number of clicks in a day and the proportions of clicks of each of the keywords remains constant. For this model we first prove that an optimal solution is a fractional prefix. In a fractional prefix the advertiser bids on all sorted keywords up to a selected keyword. In this fractional prefix last keyword in the prefix, the advertiser is assigns a probability which is the probability that he will bid on queries from that keyword. Using an interchange argument they prove that there is a fractional prefix and this fractional prefix is optimal here. Further they show that finding the optimal prefix solution is non trivial since there are local maxima. Their solution to the optimization problem overcomes the infinite number of possible fractional prefix solutions by showing that it is sufficient to evaluate a polynomial set of "interesting" solutions which depends on the number of keywords and the number of different values the total number of clicks can take, so that to solving this optimization problem by making connections to scheduling problems in wireless networks, queuing theory and the stochastic networks.

2. Independent keywords model

In independent keywords model the number of clicks for each keyword has its own probability distribution (which can be different for different keywords). The number of clicks is independent of this model. The key distinguishing feature of this model which can be different for different keywords). For this model we prove that the prefix solution may not be an optimal solution and there exists a prefix solution which is a 2-approximation to the optimal solution.

3. Scenario model

The scenario model is attempts to capture the full generality of a joint distribution without the large number of bits needed to represent an arbitrary joint probability distribution. So for this a limited (polynomial) number of scenarios in which the exact number of clicks for each word is given. A single scenario has been taken from a given probability distribution over scenarios. In this model, the authors prove two negative results: 1)The keyword optimization problem under the scenario model is NP-hard by using a reduction from CLIQUE and 2)The gap between the optimal fractional prefix solution and the optimal (integer or fractional) solution can be arbitrarily large for the optimization problem.

IV. RELATED WORK

We will only survey the online resource allocation models, Web advertising model, auctions mechanisms.

J. Feldman and S. Muthukrishnan modeled algorithmic methods for sponsored search advertising, in this large commercial search engines have emerged as information gateways for millions of Internet users. In response to a user's query, search engines generate a ranked list of results based on sophisticated information retrieval algorithms [5].

Buchbinder *et al.* showed that matching clients to webpage slots (whether it is a single slot or multiple slots) can be solved as a maximum-weighted matching problem. In the search engine environment, advertisers link their ads to (search) keywords and provide a bid on the amount paid each time a user clicks on their ads, when users send queries to search engines, along with the (algorithmic) search results returned for each query, the search engine displays funded ads corresponding to *ad-auctions* [6].

By modifying the algorithm in [7], Kalyanasundaram *et al.* the goal of online algorithm is to maximize the number of requests that is services and analyze this problem using standard competitive ratio.

Agrawal *et al.* designed a class of algorithms which achieve a considerably better competitive ratio with accurate estimates the number of query arrivals for each keyword, while still guarantee a reasonably good competitive ratio with inaccurate estimates [10].

Three learning-based algorithms in [5], [6], [7] achieve a near-optimal competitive ratio of based on a random-order arrival model (rather than the adversarial model in most of the earlier work), assuming small bids and knowledge of the total number of queries.

V. NOTEWORTHY CONTRIBUTION

Our solution is related to scheduling problems in wireless network. In particular, we use the optimization decomposition ideas in [7], the stochastic performance bounds in [3] and the modeling of delay-sensitive flows in [8]. Borrowing from that literature, we introduce the concept of an "*overdraft*" queue. The overdraft queue measures the amount by which the provided service temporarily exceeds the budget specified by a client. In making the connection to wireless networks, we define something called the "*per-client revenue region*," which is related to the concept of capacity region in queuing networks (see [9], [11]). In our context, it characterizes the revenue extractable from each client as a function of all the clients' budgets. Our online algorithm exhibits a trade-off between the revenue obtained by the service provider and the level of overdrafts. We can further modify our online algorithm so that clients can always operate strictly under their budgets. Finally, our algorithm and analysis naturally allow us to assess the impact of click-through rate estimation on the service provider's revenue. Besides the revenue maximization model, we study another model in which the objective is to maximize the average overall click-through rate, subject to a minimum impression requirement for each client. We also show that

our results can be naturally extended to handle non-stationary query arrival processes and clients which have short-term contracts with the service provider.

VI. CONCLUSION

In this paper, we propose a stochastic model to describe how search service providers charge client companies for posting their ads based on users' queries for the keywords related to these companies' ads by using certain advertisement assignment strategies. We formulate an optimization problem to maximize the long-term average revenue for the service provider under each client's long-term average budget constraint and design an online algorithm which captures the stochastic properties of users' queries and click-through behaviors. The optimization problem is solving by making connections to scheduling problems in wireless networks, queuing theory and stochastic networks. Our online algorithm is entirely oblivious to query arrivals and fully adaptive, so even non-stationary query arrival patterns and short-term clients can be handled.

In another optimization formulation where the objective is to maximize the long-term average click-through rate. The constraints include a minimum impression requirement for each client and then further we propose an approach to set impression requirements which make the contract feasible and limit the average accumulated under-service to clients.

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