An Adaptive Sponsored Search Mechanism \(\delta\)-Gain
Truthful in Valuation, Time, and Budget

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Abstract. This paper presents an online sponsored search auction that motivates advertisers to report their true budget, arrival time, departure time, and value per click. The auction is based on a modified Multi-Armed Bandit (MAB) mechanism that allows for advertisers who arrive and depart in an online fashion, have a value per click, and are budget constrained.

In tackling the problem of truthful budget, arrival and departure times, it turns out that it is not possible to achieve truthfulness in the classical sense (which we show in a companion paper). As such, we define a new concept called \(\delta\)-gain. \(\delta\)-gain bounds the utility a player can gain by lying as opposed to his utility when telling the truth. Building on the \(\delta\)-gain concept we define another new concept called relative \(\epsilon\)-gain, which bounds the relative ratio of the gain a player can achieve by lying with respect to his true utility. We argue that for many practical applications if the \(\delta\)-gain and or the relative \(\epsilon\)-gain are small, then players will not invest time and effort in making strategic choices but will tell the truth as a default strategy. These concepts capture the essence of dominant strategy mechanisms as they lead the advertiser to choose truth telling over other strategies.

In order to achieve \(\delta\)-gain truthful mechanism this paper also presents a new payment scheme, Time series Truthful Payment Scheme (TTPS), for an online budget-constrained auction mechanism. The payment scheme is a generalization of the VCG principles for an online scheduling environment with budgeted players.

Using the concepts of \(\delta\)-gain truthful we present the only known budget-constrained sponsored search auction with truthful guarantees on budget, arrivals, departures, and valuations. Previous works that deal with advertiser budgets only deal with the non-strategic case.

1 Introduction

With the advent of advertising as a pillar \cite{7} of Internet commerce, there is an acute need for improved means of increasing the value achieved by advertising agencies. In the increasingly competitive and high stakes duel between the main advertising search engines (Google, Microsoft and Yahoo!) every bit of advantage is important.

In this competition mechanism design is an important part of optimizing the monetization of search advertising. Mechanism design allows us to define allocations and
payments that maximize the welfare of participants. In doing so search engines can attract advertisers who have a strong interest (high valuation) in users interacting with their ad placements.

1.1 Problem Setting Considerations

The main tool that a mechanism designer can bring to the table is preference elicitation which essentially means finding incentives (via payment rules) that motivate the participants to honestly report their valuations for any possible allocation.

Indeed, in assuming that advertisers have a known valuation per click as well as a bounded budget, many authors have suggested algorithms that increase welfare for the search engine e.g., [1]. Some authors have even suggested mechanisms which do not assume the knowledge of CTRs but learn them while running the algorithm [17].

However we argue that the assumption of known valuations is unrealistic. In practice advertisers’ values are private information and hence advertisers might be motivated to act strategically to increase their utility. In [11] we suggest a truthful multi-armed bandit (MAB) mechanism for the case where advertisers have no budget and are always available to show an ad. Furthermore, [11] allows the different slots (possible places to display an ad) to be of different quality (although the slot quality ratio is unrelated to the advertiser).

In this paper we make the restricting assumption that the slots are of equal quality. This assumption is not necessary other than to manage the complexity of the algorithm’s presentation and allows us to express the essential elements of the model where advertisers have budget constraints as well as time constraints. We believe that this scenario captures the core nature of advertising. For example, advertisers commonly value a click through more highly in the pre-Christmas gift season than during the rest of the year.

Our follow-on paper [13] creates an auction that is truthful in budget, arrival, departure, and valuation while recognizing that slots are not of equal quality.

The budget constraint is harder to justify theoretically, inasmuch as what is important is the marginal utility from additional clicks. However, budgets decrease advertiser risk and are a standard assumption in the theory as well as a standard assumption in practice. Advertiser budgets cause a theoretical difficulty in that it is well known [6] that it is impossible to maximize welfare given the existence of budget constraints. Even when advertisers are time constrained in addition to being budget constrained [10]. Hence, we define our approximation relative to the optimal allocation under budget constraints.

Four parameters are assigned to each participant; arrival time, departure time, value per click, and budget. These parameters are private information that must be reported to the mechanism. Our results take another step toward capturing reality by allowing advertisers multiple arrivals and departures to and from the system.

Some of these parameters pose special challenges. For instance the arrival and departure times pose a challenge as [16] showed in a different context that it is impossible to achieve a truthful scheduling mechanism. [16]'s scheduling problem can hint that in our setting, there exists an impossibility of scheduling advertisers who desire a single impression with a value per click that is identical to their budget.