Impression-Plus-Click Auctions

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1. INTRODUCTION

Internet search companies generate the majority of their multibillion dollar revenue from selling ad placement, often in the form of short, textual ads that appear next to web search results. Such sponsored search ads are typically sold via pay-per-click auctions in which advertisers bid for placement, but pay publishers (i.e., search companies) only when users click on their ads. As payments are made only when ads are clicked, publishers consider both the advertiser's click bid and also the ad's quality (i.e., the probability of it being clicked) when deciding which ads to display [Edelman et al. 2007].

Standard models of sponsored search implicitly assume that the publisher and the advertiser agree on the quality, or *click-through rate* (CTR), of the ad. However, if an advertiser believes its ad to be of higher quality—and so more likely to be clicked—than does the publisher, then the advertiser would expect to pay the publisher with higher probability than the publisher would expect to be paid. Although the CTR estimates of both parties should in principle converge over time, this convergence can be slow as clicks are low-probability events. One consequence of these mismatched CTR beliefs is inefficient allocation: limited and lucrative, ad space may not be sold to those advertisers who value it the most.

In part addressing this inefficiency, we describe a truthful mechanism for impression-plus-click (IPC) auctions [Goel et al. 2009], where the advertiser pays a fixed, per-impression amount when its ad is displayed, and an additional amount when the ad is clicked. In a departure from prior work, impression and click payments may be negative, resulting in the publisher potentially paying the advertiser. For example, in a *paid*-per-click contract the advertiser pays a premium per impression, and in exchange, the publisher pays the advertiser if its ad is clicked: an arrangement that may be mutually beneficial. IPC auctions build on hybrid auctions [Goel and Munagala 2009], and are closely related to scoring rule auctions [Che 1993] and the qualitative Vickrey auction [Harrenstein et al. 2009].

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2. AUCTIONS WITHOUT MONEY

When an advertiser and a publisher disagree over click-through rates, there is necessarily also disagreement over the value of per-click contracts and, more generally, of impression-plus-click contracts. In other words, though a dollar is worth the same to both parties, a contract that pays \$0.10 per click is not. Negotiating such contracts is thus akin to trading goods in a barter economy, where the ultimate value of a commodity is in the eye of the beholder. Addressing this situation, the following qualitative Vickrey auction [Harrenstein et al. 2009] describes how to run an auction without money.

Suppose Alice is auctioning off a horse, and Bob and Charlie are competing bidders. Bob privately tells Alice he is willing to trade his goat for her horse, and Charlie likewise offers Alice 100 bushels of wheat. Evaluating the two offers, Alice decides the goat is worth more to her than the wheat, and gives Bob the horse. If Bob in return must fulfill his offer and give Alice his goat—analogous to a first-price auction—then Bob would have been motivated to bid strategically, offering the lowest bid with which he believed he could win. To avoid such strategic behavior, Bob, after winning, is instead shown Charlie's bid and is allowed to make Alice a counter-offer; Alice must accept any counter-offer that is worth at least as much to her as the best offer from a losing bidder. Bob, for example, upon learning Charlie's offer of 100 bushels of wheat might respond with an offer of 48 pecks of apples, knowing that among counter-offers Alice would accept, this is the one that he, himself, prefers.[1]

3. THE IPC AUCTION MECHANISM

An IPC contract consists of two parameters: a fixed, per-impression payment r_m, and an additional per-click payment r_c. Like goats and horses in the bartering example, the value of an IPC contract is fundamentally subjective, depending critically on the perceived probability that the ad will be clicked.

In the IPC auction, in contrast to the two-step bartering mechanism, bidders initially disclose their preferences over the entire plane of contracts; with these preferences in hand, the auctioneer acts as proxy for the bidders, circumventing the extra step for communicating a counter-offer. While fairly general preferences could in theory be supported, we focus on one particular family that is compatible with a parsimonious bidding language. Suppose each advertiser has hard caps on how much it is willing to spend for an impression and for a click, but is otherwise risk neutral. For example, an advertiser may only consider IPC contracts that charge at most \$0.01 per impression ($r_m \leq 0.01$) and at most \$1 per click ($r_c \leq 1$), and among such contracts prefers those with greater expected utility $wp-(r_m+pr_c)$, where w is value of a click to the advertiser and p is the advertiser's estimated probability its ad will be clicked. These preferences can be encoded by specifying two IPC contracts such that: (1) the contracts have zero expected utility to the advertiser; and (2) one contract realizes the advertiser's per-impression cap, and the other contract, its per-click cap. Continuing the example above, an advertiser's preferences could be

[1] Due to subtleties in tie-breaking, achieving incentive compatibility requires some additional structure on agent preferences [Harrenstein et al. 2009; Goel et al. 2009].

given by the pair of contracts $\{(-0.005, 1), (0.01, -0.5)\}$, corresponding to $w = 0.5$ and $p = 0.01$.

A bid in the IPC auction is therefore a pair of contracts, which in turn completely specifies an advertiser's preferences. Winners are determined and final contracts are selected as in the bartering auction. Specifically, for each advertiser, the publisher first identifies the contract it values most among those for which the advertiser has non-negative utility. This is the advertiser's best offer, and the winner is the advertiser whose best offer the publisher values the most. Analogous to a second-price auction, the final contract is the one most preferred by the winner among those at least as valuable to the publisher as the best offer made by losing bidders. When the publisher is risk neutral, computing the winner and the final contract from submitted bids is straightforward: a bidder's best offer is one of the two contracts that constitute its bid, and the final contract is constructed from the winner's best offer by reducing either the impression or the click payment, but not both.

Our main result is that the IPC auction is dominant-strategy incentive-compatible. That is, regardless of other bidders' actions, advertisers should submit bids that reveal their true preferences.

4. CONCLUSION

Impression-plus-click auctions are a mechanism for negotiating contracts with fixed and conditional payment components. Though we have focused on sponsored search, similar ideas may prove useful in offline transactions as well, where such considerations are often resolved informally. For example, when publishing a book, an author typically receives royalty fees (i.e., a percentage of total sales revenue) plus a one-time advance, and authors confident in their own success may be willing to accept a smaller (or even negative) advance for larger royalties. At an extreme, this amounts to self-publishing, with the author paying the production costs and keeping all the proceeds. A similar tradeoff arises with insurance premiums and deductibles: a driver who thinks he is less likely than average to get into an accident may accept relatively high deductibles in exchange for relatively low premiums. Corporate executives also face an analogous decision, in this case between guaranteed salaries and performance-based bonuses, with self-assured executives opting for bonuses in exchange for salary. In fact, though seemingly farfetched, executives may even pay to run a company in return for the possibility of large bonuses.

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