For-profit mediators in sponsored search advertising

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Abstract. A mediator is a well-known construct in game theory, and is an entity that plays on behalf of some of the agents who choose to use its services, while the rest of the agents participate in the game directly. We initiate a game theoretic study of sponsored search auctions, such as those used by Google and Yahoo!, involving incentive driven mediators. We refer to such mediators as for-profit mediators, so as to distinguish them from mediators introduced in prior work, who have no monetary incentives, and are driven by the altruistic goal of implementing certain desired outcomes. We show that in our model, (i) players/advertisers can improve their payoffs by choosing to use the services of the mediator, compared to directly participating in the auction; (ii) the mediator can obtain monetary benefit by managing the advertising burden of its group of advertisers; and (iii) the payoffs of the mediator and the advertisers it plays for are compatible with the incentive constraints from the advertisers who do not use its services. A simple intuition behind the above result comes from the observation that the mediator has more information about and more control over the bid profile than any individual advertiser, allowing her to reduce the payments made to the auctioneer, while still maintaining incentive constraints. Further, our results indicate that there are significant opportunities for diversification in the internet economy and we should expect it to continue to develop richer structure, with room for different types of agents to coexist.

1 Introduction

With the growing popularity of the Web for obtaining information via search, sponsored search advertising, where advertisers pay to appear alongside the algorithmic results, has become a significant business model and is responsible for the success of internet giants such as Google and Yahoo! The statistics show that the growth of the overall online advertising market has been around 30% every year, as compared to the 1-2% of the traditional media. The first quarter of 2007 also saw a tremendous increase in revenue from online advertising that is 26% over that in 2006. Search remains the largest revenue format, accounting for more than 40% of the 2006 full year revenues of around $17 billion.

In a search-based advertising format, the Search Engine allocates the available advertising space using an auction, where individual advertisers bid upon specific keywords. When a user queries for a keyword, the search engine (the auctioneer) allocates the advertisement space to the bidding merchants based on their bid values and their estimated fitness values. Usually, the ads appear in a separate section of the page designated as “sponsored search results,” which is located above or to the right of the organic/algorithmic results. Each position in such a list of sponsored links is called a slot. Generally, users are more likely to notice and click on a higher ranked slot, leading to more traffic for the corresponding advertisers. Therefore, advertisers prefer to be in higher ranked slots and compete for them. In a popular scheme, known as the Cost-Per-Click (CPC) or the Pay-Per-Click (PPC) model, whenever a user clicks on an ad, the corresponding advertiser pays an amount specified by the auctioneer.

From the above description, we can note that after merchants have bid for a specific keyword, when that keyword is queried, auctioneer follows two steps. First, she allocates the slots to the advertisers. Normally, this allocation is done using some ranking function. Secondly, she decides, through some pricing scheme, how much a merchant should be charged if the user clicks on her ad and in general this depends on which slot she was assigned, on her bid and that of others. In the auction formats for sponsored search, there are two ranking functions, namely rank by bid (RBB) and rank by revenue (RBR) and there are two pricing schemes, namely generalized first pricing (GFP) and generalized second pricing (GSP) which have been used widely. In RBB, bidders are ranked solely according to their bid values. The advertiser with the highest bid gets first slot, that with the second highest bid gets the second slot and so on. In RBR, the bidders are ranked according to the product of their bid value and quality score. The quality score represents the merchant’s relevance to the specific keyword, which can basically be interpreted as the possibility that her ad will

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be viewed if given a slot irrespective of what slot position she is given. In GFP, the bidders are essentially charged the amount they bid and in GSP they are charged an amount which is enough to ensure their current slot position. For example, under RBB allocation, GSP charges a bidder an amount equal to the bid value of the bidder just below her.

Formal analysis of such sponsored search advertising models has been done extensively in recent years, from algorithmic as well as from game theoretic perspectives[3, 7, 4, 1, 9, 5, 6]. For example, the existence of different types of incentive-driven Nash equilibria has been established. Further, the notion of a mediator in such position auctions has also been discussed[2]. A mediator is a reliable entity, which can play on the behalf of agents in a given game, however it can not enforce the use of its services, and each agent is free to participate in the game directly. In the paper by Ashlagi et al.[2] and the references therein, the motivation for the use of mediator comes from the search of means to implement particular outcomes, such as VCG, in a given mechanism such as RBR with GSP. However, the mediators considered so far are altruistic in nature and have no incentives, and in particular, their only goal is to implement certain outcomes despite the financial cost incurred. As we know, the marketplace is mostly about incentives- a game between selfish agents- and it would be interesting to study mediators which are not altruistic.

In our present work, we initiate a study of mediators in sponsored search auctions, which may not be altruistic in nature. We call such mediators as for-profit mediators and show that advertisers can improve their payoffs by using the services of the mediator compared to directly participating in the auction and mediator can also obtain monetary benefit by managing the advertising burden of its advertisers and in fact at the same time being compatible with incentive constraints from the advertisers who do not use its service. The simple intuition behind the above result comes from the observation that since the mediator has more information about and more control over the bid profile than any individual advertiser, she could possibly modify their bids, before reporting to the auctioneer (search engine), in a manner to improve their payoff and could retain a fraction of the improved payoff. Thus, our results show that mediators can play a significant role in sponsored search auctions, and can potentially impact the revenues earned by the auctioneer.

2 Definitions and Model Setup

In a formal setup, there are \( K \) slots to be allocated among \( N \geq K \) bidders. A bidder \( i \) has a true valuation \( t_i \) (known only to the bidder \( i \)) for the specific keyword and she bids \( v_i \). The expected click through rate (CTR) of an ad put by bidder \( i \) when allocated slot \( j \) has the form \( \gamma_j e_i \), i.e. separable in to a position effect and an advertiser effect. \( \gamma_j \)'s can be interpreted as the probability that a slot will be noticed when put in slot \( j \) and it is assumed that \( \gamma_1 > \gamma_2 > \cdots > \gamma_K > 0 \). \( e_i \) can be interpreted as the probability that an ad put by bidder \( i \) will be clicked on if noticed and is referred as the relevance of bidder \( i \). This is the quality score used in the RBR allocation rule mentioned earlier. The payoff/utility of bidder \( i \) when given slot \( j \) at a price of \( p \) is given by \( e_i \gamma_j (t_i - p) \) and they are assumed to be rational agents trying to maximize their payoffs. As of now, Google as well as Yahoo! uses schemes closely modeled as RBR with GSP. The bidders are ranked according to \( e_i v_i \) and the slots are allocated as per this ranks. For simplicity of notation, assume that the \( i \)th bidder is the one allocated slot \( i \) according to this ranking rule, then \( i \) is charged an amount equal to \( \frac{v_i + 1}{e_i + 1} \).

Let the bid profile without any mediation be (under RBB) \( v_1 \geq v_2 \geq \cdots \geq v_L > v_{L+1} > v_{L+2} > \cdots > v_K > v_{K+1} \). Now suppose that the bidders 1, 2, \ldots, \( L \) manage their bidding process through a same third party i.e. the mediator. Since the mediator has much more information about and more control over the bid profile than the individual advertisers it is likely that she could modify the associated bids in a manner to increase her payoff and that of the associated advertisers. For example, the mediator can simply bid \( v'_1 = v_1, v'_2 = \cdots = v'_L = v_L \) and she pays (under GSP) an amount \((L - 1)v_L + v_{L+1}\) which is much smaller than \( \sum_{j=1}^{L} v_{j+1} \) without mediation.

Mediator can distribute a part of this profit to the associated advertisers and therefore those advertisers along with the mediator profit at the expense of revenue loss by the auctioneer. This is the basic intuition behind why advertising via mediation can be good to the advertisers and the advertisers can stick to their traditional media companies even for advertising in sponsored search and other such auctions. However, the above intuition is of course not a formal game-theoretic argument why the collusion via mediation will work as we do also need to argue that the other advertisers (the advertisers who do not advertise via the mediator) still do not have incentives to change their slot positions. In the following we present a game theoretic analysis for the position auctions via mediation and show that the intuition given above is indeed true.

We consider the case where there is only one mediator and the analysis in the other cases essentially remains similar. The advertisers who bid via the mediator will be called \( M \)-bidders and all other advertisers will be called \( I \)-bidders. The essential features of the position auctions via mediation is:
– M-bidders report their bids to the mediator.
– M-bidders do not want to change the positions they get via directly reporting to the auctioneer\(^3\) however they give mediator the right to change their bids before reporting to the auctioneer for a potential increase in their payoffs.
– Mediator chooses a suitable set of bids for the associated advertisers and report accordingly to the auctioneer on behalf of them.
– I-bidders report their bids to the auctioneer directly.

3 Designing report-for-profit mediators

Let us first consider the RBR (rank by revenue) scheme with GSP(generalized second price) currently being used by Google and Yahoo!. The advertisers are ranked according to \(r_i = e_i v_i\) where \(e_i\) is the relevance (quality score). Let us name the advertisers by this ranking i.e. \(r_1 > r_2 > \cdots > r_L > r_{L+1} > \cdots > r_K > \cdots > r_N\), therefore the \(i\)th bidder pays \(\frac{e_i v_i}{r_i} = \frac{e_i v_i}{r_i'}\) under GSP. Let us first analyze the incentive and revenue properties for the case where the top \(L\) advertisers are the M-bidders. We will be interested in a Walrasian type of equilibria of the associated game, which is called symmetric Nash equilibria(SNE) as proposed by Varian[9] and Edelman et al[3]. However, similar analysis can be done for non-symmetric Nash equilibria and as we will note later, the mediator and the advertisers might be even more better off in the case of non-symmetric Nash equilibria. Under SNE, the bidders have no incentive to change to another positions even at the current price paid by the bidders currently at that position. Note that this is a stronger condition than usual Nash equilibrium condition which for the case of moving to higher position requires the defecting bidder to pay the bid of the advertiser holding the position currently, which is more than the price paid by her under GSP. The bids \(v_1, v_2, \ldots, v_L, \ldots, v_{L+1}, \ldots, v_{K} \) are at the SNE of the auction without any mediation, therefore in the original game the bidders have no incentives to defect from their current positions\(^5\). Now the problem is to how should the mediator modify the bids of M-bidders so as to maintain the same incentives for the I-bidders and to improve her and M-bidders\(^7\) payoffs. Here, mediator’s payoff is defined to be a fixed fraction of the total improvement in payoffs from the M-bidders over what they could have obtained without using her service, up to an additive constant.

Let the mediator modify the bids as \(r'_i = r\) for \(i = 1, 2, \ldots, l\) and \(r'_i = r_i\) for \(i = l + 1, \ldots, L\), then what \(r\) and \(l\) should she choose\(^5\). The auctioneer sees the bid profile \(r \geq r \geq \cdots \geq r > r_{l+1} > \cdots > r_L > r_{L+1} > \cdots > r_K > \cdots\). Since the original bid profile was at SNE, no \(j \geq L + 1\) would like to deviate to any other position \(s\) for \(l \leq s \leq K + 1\). Now, only position a \(j \geq L + 1\) can deviate to is the position 1 (she can not do better than this by moving to \(2, \ldots, l - 1\) for she will be paying same price to get less clicks).

The condition that the I-bidders do not want to move to position 1 is

\[
\begin{align*}
\gamma_j e_j(t_j - \frac{e_j}{r_j}) &\geq \gamma_1 e_j(t_j - \frac{e_j}{r_1}) \quad \forall j \geq L + 1 \\
\gamma_j (e_j t_j - r_{j+1}) &\geq \gamma_1 (e_j t_j - r_1) \quad \forall j \geq L + 1 \\
\vdots &\vdots \\
r &\geq (1 - \frac{\gamma_j}{\gamma_1}) e_j t_j + \frac{\gamma_j}{\gamma_1} r_{j+1} \quad \forall j \geq L + 1
\end{align*}
\]

Let

\[
r^* = \max_{j \geq L + 1} \left\{ (1 - \frac{\gamma_j}{\gamma_1}) e_j t_j + \frac{\gamma_j}{\gamma_1} r_{j+1} \right\}
\]

then any selection of \(r\) such that \(r \geq r^*\) and \(r > r_{l+1}\) is fine at SNE and the mediator chooses \(r = r^*\) and an \(l\) such that \(r_{l} \geq r > r_{l+1}\). Note that such an \(l \geq 2\) always exists as \(r \leq r_2\) (for the I-bidders did not want to move to position 1 in the original game at SNE)\(^6,7\).

\(^3\) Relaxing this condition gives more freedom to the mediator and she could possibly do even better by changing their positions as illustrated later in the paper, however advertisers might not like to go down in slot position due to decrease in traffic as well as branding impression value.

\(^4\) It is reasonable to assume this as the auction process has been going for a while now. Further, this requirement can be relaxed the mediator first bids on the behalf of the M-bidders to figure out and evolve to an equilibrium before implementing her strategy to modify their bids.

\(^5\) The bids will actually be modified so that \(r'_i = r + (L-i)\epsilon\) for an infinitesimally small \(\epsilon > 0\). In practice, this \(\epsilon\) can not be less than \(0.01\), however for the purpose of analysis, as in earlier works, we assume that it is a continuous parameter that can be made infinitesimally small.

\(^6\) Of course, the mediator will not be able to choose such a \(r\) and \(l\) all at once and will rather evolve to it by trying suitable \(r_i\)'s.

\(^7\) Sometimes for example when \(l = 2\) in the above, the mediator could possibly do even better by modifying bids as \(r_1 > r_2 > r \geq r \geq \cdots \geq r > r_{l+1} > \cdots > r_L > r_{L+1} > \cdots > r_K > \cdots\) and so on.
The mediator now pays \( (\sum_{j=1}^{l-1} \gamma_j)r + \sum_{j=1}^{l} \gamma_j r_{j+1} \) on behalf of the M-bidders and the net total gain for mediator is

\[
\sum_{j=1}^{l-1} (r_{j+1} - r) \gamma_j
\]

and the mediator can distribute a fraction of this to the associated advertisers. It is clear that this is at the expense of the loss in the revenue of the auctioneer. Note that in the case when there are only M-bidders and no I-bidders, the auctioneer gets the minimum price set for all the slots. Now let us illustrate the above analysis by an example listed in Table 1 wherein the bid profile \( \{r_i\} \) is first verified to be at symmetric Nash equilibrium in Table 2 by recalling that to verify this we need only check the equilibrium condition for one slot up and one slot down positions (locally envy free property) and finally a suitable \( r \) is chosen in Table 3.

| \( i \) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| \( \gamma_i \) | 1 | 0.6 | 0.5 | 0.4 | 0.3 | 0.2 | 0.15 | 0.10 | 0 |
| \( e_i t_i \) | 26 | 22 | 20 | 18 | 17 | 15 | 12 | 9 | 9 |
| \( r_i = e_i v_i \) | 25 | 20 | 16 | 15 | 14 | 13 | 11 | 10 | 9 |
| \( e_i PPC_i \) | 20 | 16 | 15 | 14 | 13 | 11 | 10 | 9 | 0 |
| \( r_i' = e_i v_i \) | 14.2 | 14.2 | 14.2 | 14.2 | 14 | 13 | 12 | 11 | 9 |
| reduced \( e_i PPC_i \) | 14.2 | 14.2 | 14.2 | 14.2 | 14 | 13 | 12 | 11 | 10 |

Table 1. Position based CTRs, true valuations, bid profile, and modified bid profile when \( \{1, 2, 3, 4, 5\} \) are the M-bidders (\( PPC_i \) denotes payment per click by the bidder \( i \)).

| position \( j \) | payoff: \( u_j = \gamma_j(e_j t_j - r_{j+1}) \) | payoff by defecting to \( j - 1 \): \( u_j^{j-1} = \gamma_j(e_j t_j - r_j) \) | payoff by defecting to \( j + 1 \): \( u_j^{j+1} = \gamma_j(e_j t_j - r_{j+2}) \) | SNE condition satisfied (YES/NO) |
|---|---|---|---|---|
| 1 | 1 (26 -20)= 6 | 0.6 (26-16) = 6 | YES |
| 2 | 0.6 (22 -16)= 0.5 (22-15) = 3.5 | YES |
| 3 | 0.5 (20 -15) = 0.6 (20-16)= 2.4 | 0.4 (20-14) = 2.4 | YES |
| 4 | 0.4 (18 -14)= 0.5 (18 -15)= 0.3 (18-13)= 1.5 | YES |
| 5 | 0.3 (17-13)= 0.4 (17-14)= 0.2(17-11)= 1.2 | 0.2(17-11)= 1.2 | 1.5 | YES |
| 6 | 0.2 (15-11)= 0.3 (15-13) = 0.15(15-10)= 0.8 | 0.6 | YES |
| 7 | 0.15 (12-10)= 0.2 (12-11)= 0.10 (12-9)= 0.3 | 0.2 (12-11)= 0.3 | 0.15(15-10)= 0.75 | YES |
| 8 | 0.10 (12-9)= 0.15 (12-10)= 0 (12-0)= 0.3 | 0.2 (12-11)= 0.3 | 0.15(15-10)= 0.75 | YES |
| 9 | 0 | 0.10 (9-9)= 0 | 0 | YES |

Table 2. Verifying the SNE conditions
would want to deviate to the mediator modifies the bids as maximization will be over smaller sets and the mediators could possibly do even better. In fact, in this case the \( M \)-bidder one slot down by modifying the bid profile so that \( \sum_{j=1}^{i-1}(r_{j+1} - r) \gamma_j \) can be verified as before that it is still at SNE and in fact in this case mediator’s payment on behalf of \( M \)-bidders is much lesser compared to the earlier case. This suggests that indeed the mediator could do better by moving slot positions.

If the bid profile is at non-symmetric Nash equilibrium then the mediator might do better as she can modify the bids as \( r'_i = r \) for \( i = 2, \ldots, l \) and \( r'_i = r_i \) for \( i = 1, l + 1, \ldots, L \) and the condition on \( r \) now is

\[
\gamma_j e_j (t_j - \frac{r}{\gamma_j}) \ge \gamma_{l+1} e_j (t_j - \frac{r}{\gamma_j})
\]

Now let us consider the case when the \( M \)-bidders are not necessarily the top ones but \( l + 1, l + 2, \ldots, l + L \). The mediator modifies the bids as \( r_j = r \) for \( j = l + 2, \ldots, l + s - 1 \) for some \( s \le L \) and \( r'_j = r_j \) otherwise, therefore the auctioneer sees the bid profile \( r_1 > r_2 > \cdots > r_l > r_{l+1} > r \ge r \cdots \ge r > r_{l+s} > \cdots > r_{l+L} > r_{l+L+1} > \cdots \).

As in the earlier analysis, at SNE, the only condition that need to be checked is that no \( j \le l \) or \( j \ge l + L + 1 \) would want to deviate to the \((l + 1)\)th position. Therefore, we must have for \( j \le l \) and \( j \ge l + L + 1 \),

\[
\gamma_j e_j (t_j - \frac{r}{\gamma_j}) \ge \gamma_{l+1} e_j (t_j - \frac{r}{\gamma_j})
\]

\[
\gamma_j (e_j t_j - r_{j+1}) \ge \gamma_{l+1} (e_j t_j - r)
\]

\[
r \ge (1 - \frac{\gamma_l}{\gamma_{l+1}}) e_j t_j + \frac{\gamma_l}{\gamma_{l+1}} r_{j+1}.
\]

Let

\[
r^* = \max_{(j \le l) \cup (j \ge l + L + 1)} \left\{ (1 - \frac{\gamma_j}{\gamma_{l+1}}) e_j t_j + \frac{\gamma_j}{\gamma_{l+1}} r_{j+1} \right\}
\]

then clearly \( r^* \le r_{l+2} \) and choosing any \( r \ge r^* \) and an \( s \) such that \( r_{l+s-1} \ge r > r_{l+s} \) is fine at SNE. However, in this case or in the case when \( M \)-bidders are the top ones, such a \( r \) to improve their payoffs might not always exist as can been seen by considering the example mentioned above when \( M \)-bidders are \( \{2, 3, 4, 5\} \). However, mediator could possibly improve even in these cases, if the \( M \)-bidders do not mind moving up in positions, as she does not neccecessarily have to satisfy the incentive constraints from higher position \( i \)-bidders to not change their current positions.

Similar analysis holds when there are different groups of \( M \)-bidders such that all advertisers in a group bid via the same mediator whereas different groups may have different mediators associated with them. In fact, in this case the maximization will be over smaller sets and the mediators could possibly do even better.

A possibility not analyzed above is that whether the mediator can do better by moving the positions of the advertisers either individually or sliding them all together. Consider the example given earlier and let mediator slide every \( M \)-bidder one slot down by modifying the bid profile so that \( r'_i = 12 \) for all \( M \)-bidders as shown in the Table 4. It can be verified as before that it is still at SNE and in fact in this case mediator’s payment on behalf of \( M \)-bidders is much lesser compared to the earlier case. This suggests that indeed the mediator could do better by moving slot positions. However, advertisers might not like to change positions, at least not to the lower slots due to associated branding impression values coming from higher slots and even though their payoff might increase by allowing so, they might not like to lose in terms of traffic which decreases by going down.

For-profit mediators for other mechanisms can also be designed. In particular, we discuss for-profit mediators for truthful mechanisms in the following. Truthful mechanisms are considered to be very desirable from the advertisers’ perspective since truth-telling is a dominant strategy for every one and the advertisees do not need to be sophisticated to play the auction game. However, as we argue below it is more vulnerable to for-profit mediation and even the mediators

| \( j \) | \( s_j \) | \( r^* \) | \( r \) | \( \text{improved payoff:} \sum_{j=1}^{l}(r_{j+1} - r) \gamma_j \) |
|---|---|---|---|---|
| 6 | 15-0.8 = 14.2 | 14.2 | 14.2 | 7.28 |
| 7 | 12-0.3 = 11.7 | 11.7 | 11.7 |  |
| 8 | 12-0.3 = 11.7 | 11.7 | 11.7 |  |
| 9 | 9-0 = 9 | 9 | 9 |  |

Table 3. Computing \( r \) and \( s_j := (1 - \frac{\gamma_j}{\gamma_{l+1}}) e_j t_j + \frac{\gamma_j}{\gamma_{l+1}} r_{j+1} = e_j t_j - \gamma_j (e_j t_j - r_{j+1}) = e_j t_j - u_j \) (as \( \gamma_1 = 1 \)
need not be sophisticated in this case, unlike the ones discussed earlier in this paper. In regard to position auctions, Aggarwal et al.[1] presented a truthful mechanism called *laddered auction*, which is compatible with a given weighted ranking function such as RBR, and is the unique truthful auction given this ranking function. Now, if the mediator modifies the bids of the $M$-bidders in a manner so that their slot positions (i.e. ranks) do not change, the $I$-bidders still report truthfully as its a dominant strategy. The mediator could choose such a minimum possible bid profile to get the best improvement in payoffs and in particular modifying every $M$-bidder’s bid to a value only infinitesimally more than just enough to retain the position of the least ranked $M$-bidder suffices.

### 4 Concluding Remarks and Future Work

Sponsored search advertising is a significant growth market and is witnessing rapid growth and evolution. The analysis of the underlying models has so far primarily focused on the scenario, where advertisers/bidders interact directly with the auctioneers, i.e., the Search Engines and publishers. However, the market is already witnessing the spontaneous emergence of several categories of companies who are trying to mediate or facilitate the auction process. For example, a number of different AdNetworks have started proliferating, and so have companies who specialize in reselling ad inventories. Hence, there is a need for analyzing the impact of such incentive driven and for-profit agents, especially as they become more sophisticated in playing the game.

Our results show that there are significant opportunities for diversification in the market and the emergence of incentive-driven equilibria. Thus, we should expect the adword auction market to continue to develop richer structure, with room for different types of agents to coexist. Another implication of our results applies to the traditional media. Publishers of traditional media, such as newspapers and network TV and radio, have seen significant declines in their audience market shares, as more people have shifted to the Web as the source for information and entertainment. Their advertising revenues have decreased significantly as well. Our results show that one way these traditional media players can retain the loyalty of their advertisers is to manage their online auctions! By mediating their auctions, they can provide better payoffs to their clients, and thus prevent them from switching allegiance to the online giants, such as Google and Yahoo! Other than creating a new revenue source for the traditional media businesses, it would allow them to retain their own networks and give them precious time to reposition themselves and figure out the best possible ways to take their content online, and compete effectively in a new market space.

Our present work on the diversification in the internet economy is only the tip of the iceberg. Further investigation is likely to give better insights. For example, one natural constraint on the sponsored search auction comes from the fact that there is a limit on the number of slots, in particular for the popular keywords, which limits the number of advertisers that can be accommodated and it is likely that new market mechanisms as well as new for-profit agents will emerge to combat or to make profit from the opportunities created by this capacity constraint, leading to a diversification in the market. We are investigating this direction in a related work[8]. Further, even in the case of for-profit mediators studied in the present work, several directions are left to explore. For example, do there exist mechanisms which are impervious to collusion via for-profit mediation and if they do how do they effect the revenue of the auctioneer? Furthermore, more sophisticated mediators such as where $M$-bidders need not be consecutive should also be investigated and in general if the mediator is sophisticated enough to exploit her best possible strategy, how does the modified profile look at equilibrium? Furthermore, for-profit mediators for other auction formats should also be interesting to study.
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