DISARMING THE BID SNIPER

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ABSTRACT

Bid sniping is the most common strategy used in online auctions whereby the bidder places a bid in the closing seconds in order to win the auction. This denies other bidders the time to react and suppresses the final price. While bid sniping is beneficial to the winner, it disadvantages other bidders and the seller does not get the full amount of revenue s/he might otherwise have received in a truly competitive and fair auction. This paper proposes a method to help negate bid sniping as a dominant strategy for winning in online auctions. We propose an amendment to the auction format that allows for a random undisclosed time-out extension should new bids be received in the closing moments. This entices bidders to bid their true valuation up front, otherwise they risk having the auction terminate and therefore not accept any new bids. Several variations of the amended auction format are presented that effectively counteract bid snipers by making it difficult to gain any information by observing the underlying algorithm. To ensure the auction does not continue indefinitely, the format includes mechanisms that place random bounds on the size of, and number of extensions permitted. Our proposal also makes intelligent decisions to maximize the price for the seller based on the auction's bid volume. The size of the extension granted is based on the timing and aggressiveness of how bids are being submitted. To our knowledge, no existing online auctioneers offer such a comprehensive format for actively discouraging bid sniping.

Keywords: Online auctions, e-commerce, software bidding agents, sealed bid auction, proxy bids

1. Introduction

Online auctions are a highly successful mechanism to trade items from the comfort of one's own home. However, the move towards an automated marketplace has resulted in changes to the auctioning structure that has many undesirable consequences. The majority of online auctions terminate at a preset expiration time. This characteristic allows bidders to engage in a dubious bidding practice referred to as *bid sniping* (see [Bapna 2003, Wenyan and Alvaro 2008, Leonardo and Ruy 2009, Shah et al. 2002, Trevathan et al. 2011]).

Bid sniping is an act by which a bidder submits a bid in the closing moments of an auction. The goal is to deny competing bidders the time to react. The bid sniper hopes that his/her bid will win the auction for the minimal amount needed. This is in contrast to regular bidders that bid competitively throughout the auction. By deferring bidding until the auction's end, the bid sniper will minimize the risk of being outbid and having to engage in a rally with other bidders, which inevitably pushes the price upwards [Elay and Hossain 2009].

While bid sniping is not illegal, its use is discouraged by the major online auction vendors. Instead, *eBay*[1] recommends that a bidder should only place a single bid at his/her maximum valuation using the *proxy bidding system* (i.e., submit the maximum amount and have the system automatically outbid rivals until the maximum is exceeded) [Engelberg and Williams 2009]. Despite this recommendation, bid sniping is rampant, and is now considered as a natural part of the online auctioning experience. In fact, economists and business analysts advise that bid sniping is the best and most common strategy to use (see [Roth and Ockenfels 2002, Shah et al. 2002, Vergano 2006]).

Some bidders have now even resorted to using software bidding agents to gain a competitive advantage. A software bidding agent is a program that bids on a human bidder's behalf (see [Dumas et al. 2002, Gjerstad and

[1] www.ebay.com

Dickhaut 1998, Rust et al. 1992, Trevathan and Read 2008]). In the ideal (and intended) sense, the user enters a maximum s/he is willing to pay. The agent will incrementally outbid competitors up to the maximum price. This saves a human the effort of constantly having to monitor an auction for bidding activity (as some auctions can last for days). eBay's proxy bidding system is an example of such a bidding agent. However, there are commercial bidding agents that now offer *bid sniping services*.

A *bid sniping agent* is an automated program that monitors an auction and then submits a bid during the closing moments. Bid sniping agents give their owners an advantage over ordinary bid snipers. Firstly, the human does not have to monitor the auction, and secondly the reaction time can be down to fractions of a second from the closing time. As a result, it is humanly impossible to compete unless everyone begins to employ bid sniping agents. This then raises serious questions over the effectiveness of online auctions to produce the maximum value for the seller given the prominence of bid sniping.

The problem with bid sniping is that it denies a seller revenue that might have otherwise been obtained through a competitive bidding process. It also frustrates other bidders who find that they have only lost during the closing seconds to a minimal bid – which they might otherwise have attempted to outbid. The situation is so common that most auctions now have degraded into a competition between snipers during the closing seconds. In general, only a novice or naive bidder bids early as s/he will have to pay more for the item, or will lose the auction [Elay and Hossain 2009, Wenyan and Bolivar 2008]. Having the majority of bidders sniping reduces auctions to a *sealed-bid* format (see [Vickrey 1961]). Some economic studies have shown that sealed bid auctions have a lower average revenue compared to open bid style auctions [Milgrom and Weber 1982].

This paper presents a method to make bid sniping less attractive as a strategy for winning in online auctions. We propose an amendment to the auction format that allows for a random undisclosed time-out extension beyond the initial announced firm deadline should new bids be received in the closing moments. The proposed format encourages bidders to bid their true valuation up front. Any delay in bidding will come at the risk of not having one's bid included in the auction (as it will be received after the auction closes). Note that several commercial auctioneers such as *Amazon*[2], *Trade Me*[3] and *Yahoo Auctions Japan*[4] do offer a "basic" version of this approach. However, we present several more sophisticated variations of the amended auction format that effectively counteract bid snipers by making it difficult to gain any information by observing the underlying algorithm. To ensure the auction does not continue indefinitely, the format includes mechanisms that place random bounds on the size of, and number of extensions permitted. It also makes intelligent decisions to maximize the price for the seller based on the auction's bid volume, and the size of extension granted is influenced by the timing of when bids are placed. To our knowledge, no existing online auctioneers offer such a format for actively discouraging bid sniping in this manner. Only [Malaga et al 2010] have proposed a similar idea (but less advanced) for curbing bid sniping.

This paper is organized as follows: Section 2 describes general bid sniping behavior and the problem motivation. Section 3 proposes an amendment to the online auction format to counter bid sniping. Section 4 discusses how our proposal differs to any existing service that is currently employed by commercial auctioneers. Section 5 provides some concluding remarks and avenues for future work.

2. Bid Sniping in Online Auctions

This section provides insight into a bid sniper's strategy, how prevalent and problematic bid sniping actually is in commercial online auctions, and how a commercial bid sniping agent operates.

2.1. A Bid Sniper's Strategy

Winning and paying the minimal amount at or below the true valuation is generally the goal of all bidders in an auction. However, the strategy employed by a sniper is very specific in order to achieve such an outcome. By studying eBay auctions where sniping had occurred, results from the literature [Milgrom and Weber 1982, Roth and Ockenfels 2002, Tan et al 2009], and through practical experience at sniping ourselves [Trevathan et al 2011], we determined the core strategies for being a successful sniper in an online auction.

The following outlines the major strategy/goals a bid sniper will follow:

- *Win the auction:* The sniper is in the game to win, and will bid accordingly to ensure that this happens.
- *Only pay the minimal price subject to a valuation:* While a sniper's main goal is to win, s/he will not do this at any cost. In reality the sniper is only prepared to pay an amount up to a set valuation. If the sniper does happen to be outbid, s/he will only bid up to this valuation within the constraints of the time remaining in the auction.

[2] www.amazon.com
[3] www.trademe.co.nz
[4] auctions.yahoo.co.jp

- *Submit as few bids as possible:* A sniper only wants to submit one, or in the worst case, a few bids. The more bids that are submitted, the higher the auction price will be. In general, the sniper will only submit as many bids as are necessary up to the target valuation. The availability of the item or the existence of auctions with similar items could also influence the sniper's decision to submit bids. If the sniper is being forced to submit more bids, s/he may simply give up and focus on another auction for the same item where the price is lower.
- *Has a preference towards auctions with a lower bid volume:* A high bid volume suggests that there is a significant amount of competition for an item. In general, the more bids that have been submitted in an auction, the higher the price will be. A sniper will be reluctant to participate in an auction with high bid volume, and will instead opt for an auction with a low bid volume and price. It is in such an auction that the sniper will be most likely to "steal" the item for the minimal price.
- *Avoid bidding rallies:* Bidding rallies occur when two or more bidders aggressively outbid each other in an attempt to win. A sniper will avoid bidding rallies as this is a logical extension of behaviors 3 and 4 above.
- *Avoid large proxy bids:* Timing is of the upmost importance to a sniper. The sniper must place a bid that is large enough to get ahead, but allow the possibility of submitting further bids if the initial bid is not large enough to get in front of a competitor's proxy bid. However, the bid must not be too large so that competing late bidders force the bid up to its maximum. Therefore, a series of smaller proxy bids is a safer option provided that these can be submitted prior to the auction ending.

A sniper is considered to have been *successful* if s/he has won the auction for a price less than or equal to his/her true valuation. The sniper is deemed to have been *unsuccessful* if s/he has not won the auction as s/he was outbid and was unable to enter a competing bid on time, or s/he was outbid and the competing bid is higher than his/her true valuation. The first instance is more of a frustration to the sniper, whereas the second scenario is an outright loss. A sniper can also be considered as having been unsuccessful if s/he has won the auction, but was forced to pay more than his/her true valuation.

The sniper's main source of competition includes proxy bids and other snipers. As a sniper is bidding close to the auction's end, if s/he runs up against a proxy bid for more than the bid s/he has submitted, then s/he must submit a new higher bid in order to win. The sniper has two possible strategies in this situation. Firstly, s/he can keep submitting new bids in an incremental manner until s/he outbids the proxy bid. However, this approach is contingent on the amount of time remaining in the auction. The sniper might actually run out of time before s/he has outbid the proxy bid. Alternately, the sniper might submit a proxy bid for an amount up to his/her true valuation. If this is greater than the rival proxy bid, then s/he will win. However, in doing so the sniper has revealed his/her true valuation, and runs the risk of other late bidders competing with him/her, thereby raising the price.

Competing snipers are the second main cause of concern for a bid sniper. It is common for several snipers to enter competing bids during the closing seconds. This will force a bid sniper to have to enter several bids quickly in order to remain ahead. This is undesirable for a sniper as the price is run up, and bidding becomes more erratic, potentially leading to errors such as bidding more than the true valuation.

2.2. The Prominence of Bid Sniping in Commercial Online Auctions and Why it is a Problem

[Shah et al 2002] performed a data mining study into the amount of sniping in 12,000 eBay auctions. Their results showed bid sniping (or late bidding) is the most common behavior among bidders for the majority of auctions. [Roth and Ockenfels 2002] also observed that 18% of the bids were made in the last 60 seconds. [Trevathan et al 2011] more recently analyzed data from 4,298 eBay auctions. They concluded that the majority of auctions have late bids (in the last 60 minutes), and a significant proportion of bidders only commence bidding in the final 60 minutes and submit very few bids – consistent with a bid sniping strategy. [Wenyan and Bolivar 2008] at *eBay Research Labs* analyzed the bidding patterns of auctions held on eBay. They discovered that bidders who snipe have a winning rate of 66.73%, whereas non-snipers had a winning rate of 21.79% and submitted about five bids in order to win. [Wenyan and Bolivar 2008] also pose that in general, the winning rate for a bidder increases the closer to the auction's end that s/he bids.

So what effect does bid sniping have on the auctioning process?

The first issue is that regular bidders are frustrated (i.e., those not using a sniping strategy). Such bidders will typically have been following the auction for days. They then become disgruntled when they lose in the closing seconds to a new bid. The winning bid will typically have been for a minimal amount, which competing bidders might otherwise have attempted to outbid. However, the short time prior to the auction's end has denied the bidder time to respond.

The next issue is that sniping induces other parties to snipe. Eventually, bidders learn that the only way to win or compete with snipers is to engage in sniping themselves. This is evident in the analyses from literature on the prominence of bid sniping in commercial online auctions. When the majority of bidders engage in sniping, then the auction is skewed towards a sealed bid format. In a sealed bid auction, bids are submitted secretly to the auctioneer in that the other bidders do not know the values of each others' bids [Vickrey 1961]. This drastically confuses the auction rules for online auction formats. That is, up until the closing time all bids are public, but in the closing seconds a mass of confusing signals are sent out and no one really knows what the true values of bids are. This problem is exacerbated by proxy bids.

eBay recommends that bidders submit their bids early for their true valuation via the proxy bidding system (consistent with a dominant bidding strategy) [Engelberg and Williams 2009]. However, there are problems with this approach. Firstly, an early proxy bid opens the bidder to the prospect of shill bidding where a competitor (usually in league with the seller) inflates the price by incrementally bidding away at the proxy bid [Trevathan and Read 2008]. Furthermore, proxy bidding is a completely different strategy to bid sniping. Both are a dominant strategy, but the latter is more cautious and is designed to suppress price inflation. Furthermore, if everyone follows a proxy bidding strategy, then the auction will become a sealed bid auction.

From the aforementioned points, bid sniping clearly promotes price suppressing behavior which is anti-competitive for the seller. Such behavior denies the seller revenue that might have otherwise been obtained through a competitive bidding process. An economic study by [Milgrom and Weber 1982] showed that sealed bid auctions have a lower average revenue compared to open bid style auctions. The lower revenue is due in part to sealed bid auctions reducing the effects of the *winner's curse* [Bajari and Hortacsu 2003]. The winner's curse is a phenomenon that a winner may overpay in that: 1) the winning bid exceeds the value of the item, and the winner is worse in absolute terms; or 2) the value of the item is less than the bidder anticipated. It is argued that having an open format furnishes bidders with valuable information, and therefore reduces the risk of making an uninformed decision in the 'heat' of sniping where there is a lack of information regarding others' bids. However, there is mixed evidence regarding the economic effects of sealed bid auctions and how effective bid sniping is. In the absence of a definitive answer to which auction format produces the best outcome, alternate schemes such as reducing bid sniping need to be pursued.

The next issue is whether a soft close auction (i.e., an auction with time-out extensions) will deliver a better outcome for the seller than a hard close format (i.e., an auction that terminates at a firm deadline and does not allow extensions) [Onur and Tomak 2006]. This paper does not attempt to justify this argument. Instead, the goal is to propose a counter measure to neutralize the effect of bid sniping so the auction operates in the same manner as an open bid auction, which has been shown to deliver a better price for the seller and also provides all bidders the opportunity to submit further bids at the auction's close should there be competition.

2.3. Existing Bid Sniping Programs/Vendors and Why Bid Sniping Agents Exacerbate the Problem

A *bid sniping agent* is a software bidding agent that follows a late bidding strategy [Tan et al 2009]. The sniping agent constantly monitors an auction, and waits until the last moment to bid. Many companies now exist such as *Bidnapper.com*[5], *ezsniper*[6] and *Auction Sniper*[7] which offer sniping services for eBay auctions. These companies actively promote the sniping strategy, touting that "everybody does it" and it is the optimal strategy to "win more auctions". They point to literature to back their position (e.g., [Roth and Ockenfels 2002, Vergano 2006]).

A bidder either subscribes for a fee, or pays on a per use basis for each auction the sniping services are required in. It is not necessary for a customer to download proprietary software, nor is s/he obligated to be permanently connected to the Internet. Instead, the customer provides the sniping service with account credentials (i.e., user name/password), a list of auctions, and the maximum price s/he is willing to pay for each respective item. The sniping service hosts dedicated servers that continually monitor online auctions and place sniping bids directly with the auctioneer.

As the sniping service is not actually part of the auctioneer, it must periodically poll the auctioneer's servers for accurate information. The speed at which the sniping service can react is limited by the physical connection to the auction server, and therefore it is susceptible to network delays. Bidnapper has gone to the extreme lengths of placing local servers in the same countries/regions as the auctioneer's servers in order to minimize the effect of network delays. The resources and dedication of such sniping services is a testament to their profitability.

While bid sniping services are convenient, there are several issues to consider with their use:

[5] http://www.bidnapper.com
[6] http://www.ezsniper.com
[7] http://www.auctionsniper.com

- Is bid sniping ethical? (See [Marcoux 2003].)
    - Is bid sniping something commercial companies should be condoning and profiting from?
    - If online auctioneers discourage its use, why don't they pursue perpetrators or try to prevent the activity?
- Users of bid sniping services should also consider whether they are comfortable with providing their personal account credentials:
    - Are these credentials being stored and/or transmitted securely?
    - What is preventing them from being misused?
- What happens if two bidders request to snipe the same auction?
    - Does the sniping service vendor take money from both of them knowing full well the bidder with the higher valuation will win?
- Does the sniping service operate in a consistent manner each time, or does a human make an opinionated judgment to influence its operations?
- Is it fair if a bidder employs the services of several sniping agents on a particular auction to almost guarantee victory?
- Are there any other types of undesirable behavior that arise from, or are used in conjunction with bid sniping?

Note that this discussion does not seek to vilify those who use a bid sniping strategy. Bid sniping is the best strategy to employ in order to win (more on this in Section 3). Rather, it is the auction format adopted by the majority of online auctioneers that is the problem as it facilitates and encourages the need for bid sniping.

3. Countering Bid Sniping

This section proposes methods that can be used to proactively discourage bid sniping.

At present, the only preventative measure for a bidder against sniping is to "out-snipe" the sniper. That is, if one observes a sniper bid, outbid the sniper marginally at a time even closer to the auction's end. However, this is a risky approach, and it all comes down to timing. Effectively, the person with the quicker connection will be the winner.

Employing this strategy often results in there being *multiple snipers* in an auction. This behavior leads to failure of the English auctioning process. If everyone engaged in sniping, the auction would essentially become a *sealed bid* auction [Vickrey 1961]. English auctions on the other hand are *open bid*, and allow bidders to bid multiple times. In a traditional offline English auction, sniping cannot occur. Sniping is a feature unique to online auctions. Sniping behavior blurs the boundaries of an online auction between the type of auction it is and the rules that govern it.

The same argument could be made for all bidders submitting their bids as a proxy bid as a method to avoid bid sniping. This also reduces the auction format being sealed bid. In reality, having the majority of bidders as snipers or all bids being submitted as proxy bids are extreme scenarios that will not occur often. It is the variety of bidding strategies present that raises the ambiguity that allows bid sniping to be a successful strategy.

3.1. Components of an English Auction

In order to participate in an auction, a bidder must *register*. S/he is provided with a unique bidder id, b_{id}, which is used to submit bids (note the subscript $_{id}$ stands for id or identity). During the *initialization* stage, the auctioneer sets up the auction and advertises it (i.e., item description, starting time, etc.). An auction is given a unique number, a_{id}, for identification purposes. In the *bidding* stage, a bidder computes his/her bid and submits it to the auctioneer. The agent can place a bid in auction a_{id}, for price p', by invoking the **submit bid(a_{id}, p')** function.

The auctioneer must *supply intermediate information* to the agent pertinent to the auction's current state. The agent can request a price quote for a particular auction by invoking the **obtain price quote(a_{id})** function. This includes the start time T_0, end time T, and current time T_c for the auction (where $T_0 \leq T_c \leq T$), the starting bid (if one exists) and the current price p. It is assumed that everyone has access to the entire bid history up to the current time in the auction. The history can be considered as an ordered set $H = \{h_1, h_2, ..., h_n\}$, $|H| = n$, that contains price quote triples $h_i = (t_j, price, b_{id})$, where $1 \leq i \leq n$. t_j is the time the bid is submitted where $T_0 \leq t_j \leq T$. The last element is the latest price quote for the auction (i.e., h_n is the current highest bid).

During the *winner determination* stage, the auctioneer chooses the winner according to the auction rules (e.g., who has the highest bid, whether the reserve has been met, etc.).

3.2. Introducing Time-Out Extensions

We propose a new method to prevent bid sniping by using a *time-out period* at the end of an auction. The whole problem of bid sniping was introduced as a result of online auctions having a predetermined expiration time.

In a traditional (offline) English auction, the auction terminates when no new bids are received after a given time-out. For example, the auctioneer calls "going once", "going twice", and then if no new bids are forthcoming, "sold". If a new bid is made, then the auction continues until the timeout occurs again with no new bids being submitted. Bid sniping is unheard of in this style of auctioning as it essentially cannot occur.

In terms of an online auction, we desire to capture this style of behavior to deter and effectively render bid sniping ineffective. The new auction mechanism could still terminate at a predetermined time. However, if a new bid is received within the closing moments, then the auction is automatically extended to give other bidders the time to consider the new bid. For example, if a new bid is submitted, the auction may extend by ten minutes beyond the official closing time. (Note that the extension period and new closing time would be publicly announced.)

The following equation is used to denote this behavior:

$$T = T + 10 \text{ mins} \tag{1}$$

Once the auction extends beyond its termination time, it enters what we refer to as the *provisional period*. That is, only bidding activity is keeping the auction going. When further bids are received during the provisional period, then the auction is extended further to allow for new bids to be received. If no bid is received during the provisional period, then the auction terminates once the extension time elapses.

Equation 1 can be generalized for the provisional period. Let E_i denote the ending time of the ith extension. ΔE_i is the amount of time in the ith extension where $\Delta E_i = E_i - E_{i-1}$. Then for any bid received during an extension, the following equation is used to further extend the auction's time:

$$E_i = E_{i-1} + \Delta E_i \tag{2}$$

Here $\Delta E_i = 10$ mins. However, ΔE_i can be chosen to be any reasonable amount of time.

Now let us consider what effect this will have on bid sniping. If a sniper bids, then the auction is extended (say for ten minutes). This gives other bidders the time to react. If another bidder does submit a bid (during the provisional period), then what options are available to the bid sniper? The sniper could bid straight away. However, this would potentially result in a rally with the regular bidder. Instead, the sniper would most likely wait until the final seconds of the provisional period to submit a bid, but doing so will result in the auction being further extended by ten minutes.

3.3. Random Undisclosed Time-Out Extensions

In its simple form, the aforementioned strategy has largely reduced the effect of bid sniping. However, it still seems that the sniper's best approach is to wait until the closing seconds of the provisional period. Doing so allows the sniper to wage a war of attrition against other bidders who either may not be watching the auction closely, or who get disgruntled and go to another auction as they really desire the goods immediately (e.g., in the case of an airline ticket for a plane that is due to leave).

Likewise, often the seller needs the auction to close by a certain time that is not a direct consequence of the good up for auction. For example, the seller may be travelling, taking extended leave and need to finalize the auction before leaving. Alternately the seller may be auctioning items to finance another venture where there is a critical timeline, not related to the auction goods. Another example is a scalper trying to sell tickets to the opera really needs to sell those tickets before some point prior to the start of the opera. Under these conditions such strategies all reduce to the optimal case for the auctioneer.

These scenarios raise the question, how long can the auction be extended for? If the commodity being sold is of a transient nature (i.e., it is perishable or its value depends on time – such as fresh food, concert or lotto tickets, a product with financial advice about a timely opportunity, etc.), then it may be undesirable for the auction to continue on with an indefinite amount of timeout extensions. Note that 'indefinite' only means past a sensible date for an auction's conclusion based on the nature of the goods and the seller's expectations. (A full investigation of this phenomenon is the focus of future work.)

To avoid this problem and to further force a bid sniper to behave like a regular bidder, the timeout strategy can be slightly altered in the following manner. Firstly, the auctioneer does not need to announce exactly how long the provisional period is for each extension granted. An unknown randomized time-out extension will essentially spur bid snipers to bid immediately and up to their true valuations. Any delay in submitting a bid might result in the sniper not being able to place a bid before the auction terminates and as a result, the sniper misses out on the opportunity to participate. [Malaga et al 2010] also proposed a similar approach to using randomized auction ending times although their scheme does not include time-out extensions.

Secondly, over time the bid sniper will eventually work out exactly how long the provisional extension is through trial and error if the extension time is keep constant. To avoid this problem, the auctioneer can make the extension *random*. For example, it may be ten minutes the first time, four minutes the second time, eight minutes the third, etc. To capture this behavior, equation 2 needs to be modified. Let x denote the maximum possible value for ΔE_i. ΔE_i cannot be 0 as this would mean the extension would not have any time. Therefore a tolerance value δ is required such that:

$$\delta \leq \Delta E_i \leq x$$

where δ ensures that the extension is at least a minimum amount of time (e.g., 30 seconds). If r is a function that returns a random number between 0 and 1, then ΔE_i can be assigned a random amount of time as follows:

$$\Delta E_i = [r(1-\delta)+\delta]x$$

Substituting ΔE_i into Equation 2 gives

$$E_i = E_{i-1} + [r(1-\delta)+\delta]x \qquad (3)$$

The auction now has a *random undisclosed time-out extension* format.

3.4. Intelligent Time-Out Extensions

To practically implement the time-out extension raises the following questions:

1. How many extensions are permissible?
2. What is the maximum time each extension should be?
3. Does auction duration affect 1 and 2?
4. How far from the auction's termination should a new bid influence a decision to extend the auction?
5. Should 1 and 2 be subject to the current bid volume?
6. Should the random size of the extension decrease the further into the provisional period the auction runs?

All of these questions are inter-related. We will deal with each in turn with an increasing level of complexity.

Number of Permissible Extensions – First of all, the auction cannot continue indefinitely by granting a limitless number of extensions. To ensure that an auction doesn't continue indefinitely, an undisclosed random bound on the number of time-out extensions can also be used. The following pseudo code illustrates the logic:

1. $i = 1$, $m = \lceil 1 + r(y-1) \rceil$ (where $y \geq 1$)
2. while ($i < m$)
   a. $i = i + 1$
   b. $E_i = \Delta E_{i-1} + \Delta E_i$

Where x is the maximum extension time permitted and y is the maximum number of timeout extensions allowed. Note that $m = \lfloor 1 + r(y-1) \rfloor$ ensures that the random generator always gives at least one extension.

Maximum Extension Increment – In Equation 3, x was arbitrarily assigned a value. However, if a sniper can work out the value of x, then s/he gains some information that can potentially be useful in terms of delaying his/her bid. To make it more difficult for a sniper, x should be altered for each auction. Furthermore, an extra layer of complexity can be added by making the extension increment "double random". That is, not only is the size of the extension randomly chosen, but the value of x is also randomly chosen as follows:

$$x = [r(1-\varepsilon)+\varepsilon]z \qquad (4)$$

where z is the maximum value x can be and ε is a tolerance value to ensure x is above a minimal amount. For example, ε can be set as a percentage of z.

By using this approach, there are significantly more possibilities a sniper must deal with when attempting to guess the value of the timeout extension.

The Effect of Auction Duration – The next issue is whether an auction's duration should affect the maximum timeout extension amount and how many extensions are permitted. For example, if an auction is of one day in duration, should x and y be less than an auction that is of a ten day duration?

A possible justification in favor of increasing x and y with longer auctions is that the auction has gained significant exposure and may potentially attract more bids than a shorter auction. Furthermore, a short auction (e.g., a one day auction) has been deliberately assigned a short duration, therefore it may be the seller's intention to have it terminate faster than a longer auction. For example, in an auction for a perishable item such as fish, it is undesirable to provide any significant extension.

However, based on the analysis presented in Section 3 and the results given in [Balingit et al. 2009], we found that auction duration does not significantly affect the bid volume or does it radically alter bidding behavior. As such, the anti-sniping format proposed in this paper operates the same regardless of auction duration.

The Influence of Auction Termination Time – The analysis from Section 3 shows that largest increase in the percentage of bids placed in an auction occurs in the final 15 to 5 minutes. Therefore, we choose to have bids submitted in the final 5 minutes initially trigger the first timeout extension (referred to as the *triggering period*). By directly observing sniping behavior and through practical experience, we discovered that serious snipers rarely won if they bid sooner than 5 minutes prior to the closing time. In fact, in a competitive sniper environment it often comes down to the final 30 seconds. Therefore, 5 minutes seemed reasonable for the initial triggering period.

When a new bid is received within the final 5 minutes, then the auction is extended from the auction termination time T for an amount of time determined by ΔE_1. Note that the auction is **not** extended from the point in time the bid is received during the triggering period, but from T. Likewise, as soon as a bid is received during the ith extension in the provisional period, then the auction is only extended from E_i by ΔE_{i+1}, not from the point in time when the bid is submitted.

To ensure that the auction closes as soon as possible into the provisional period, it is undesirable for the triggering period of an extension to be equal to the entire length of the extension. That is, if the extension is for ten minutes, then any bid placed anywhere within the ten minutes shouldn't automatically trigger a further extension. Rather, preference should be given to later bids in the provisional extension period to trigger a further extension.

We divided the extension into two intervals. When at least one bid is received in the second interval, then another extension is triggered. We can represent this mathematically as follows.

Let E_{i-1} and E_i denote the start and end time of extension i. Let $t_{i,j}$ denote the time of the jth bid in the ith extension respectively. A value α (where $0 \leq \alpha \leq 1$) can be assigned to the ith extension such that once the time has passed this point (denoted as $E_{i,\alpha}$), then the auction has reached the triggering period. This is calculated as follows:

$$E_{i,\alpha} = E_i + \alpha \Delta E_i$$

When $t_{i,j} \geq E_{i,\alpha}$ another extension is triggered. Bids submitted prior to $E_{i,\alpha}$ do not trigger an extension.

The choice for α can be left up to the seller. If $\alpha = 0$, then any bid submitted within the triggering period automatically extends the auction. Likewise, if $\alpha = 1$, then no bids can influence the auction's time.

The Effect of Bid Volume – There are two main arguments to the effect of bid volume. Firstly a high bid volume may suggest that there is significant competition for the item on auction. In this case it is desirable to let the competition run up the price as much as possible. Therefore, the auction provisional period can be slightly longer than an uncompetitive auction. However, the counter argument is that the results from [Balingit et al. 2009] showed that the average number of bids submitted in an auction is 32. Therefore, if the number of bids in an auction has exceeded 32, then it is unlikely that extending the provisional period will have any effect on the auction.

Depending on the school of thought, the basic approach for factoring in bid volume is as follows. Let ξ denote the minimum interval length and m_i the number of bids in the ith extension. m_0 is the number of bids in the auction. N is the total number of bids in a global maximum (e.g., 32). Let x_i be the maximum possible time allowable for extension i, then:

$$x_i = \min\left[\frac{m_{i-1}}{N}, 1\right] X$$

where X is the global upper bound on the amount of time permissible.

Let $r = \min[\frac{m_{i-1}}{N}, 1]$, then:

$$x_i = [r(1-\varepsilon) + \varepsilon] X \quad (5)$$

This allows the amount of time in the provisional period to be extended when there is high bid volume. Inversely:

$$x_i = [(1-r)(1-\varepsilon) + \varepsilon] X \quad (6)$$

allows the amount of time in the provisional period to be shortened if the average number of bids exceeds the global average.

The above approach to factoring in bid volume can also be refined by taking into account where the most bids have been placed in the auction. Auctions with significant bid volume at the beginning of the auction would appear to be less lucrative than those with more bidding towards the end, and/or those with uniform bidding throughout the auction.

To capture this behavior we take the "average" of the bids made in the ith interval as follows:

$$\frac{\sum_{j=1}^{J_i} t_{i,j}}{J_i}$$

where J_i is the number of bids in extension i. J_0 is the number of bids in the auction.

Next we scale the average from 0 to 1 to use as a weight rather than using a purely random assignment for an interval's length:

$$\tau_i = \frac{\frac{\sum_{j=1}^{J_i} t_{i,j}}{J_i} - E_{i-1}}{E_i - E_{i-1}} \quad (7)$$

Let r_i be the random value for interval i. Then τ_i replaces r for the particular interval

$$r_i = \tau_{i-1}$$

The Influence of Provisional Time Elapsed – As the number of timeout extensions granted increases further into the provisional period, the amount of time for further timeouts should decrease. This is to ensure that the auction terminates sooner rather than later. While the previous mechanisms do this to some extent, this is an explicit way of smoothing out an auction's provisional period. Let n denote the number of extensions granted so far. Then there is an inverse relationship between n and ΔE_i. Equation 3 is modified as follows:

$$\Delta E_i = \frac{[r_i(1-\delta)+\delta]x}{(n+1)^{\beta}} \text{ mins} \quad (8)$$

As n increases, the effect of the random size of x decreases. To slow this behavior down, a tolerance value β can be added to n to ensure that a reasonable number of extensions are permitted before the smoothing takes effect. For values of $\beta < 1$, the length of extensions slowly decreases. For values of $\beta > 1$, the length of extensions dramatically decreases.

4. Comparison with Similar Services

There exist several online auctioneers that do offer a timeout extension format to help prevent bid sniping. This section briefly examines how these services work and outlines how our proposed format differs.

Trade Me is a prominent online auction company in New Zealand. The triggering period in Trade Me is the final 2 minutes and auctions are extended by 2 minutes from the time a bid is placed. *Amazon* and *Yahoo Auction Japan* also offer online auctions that can be auto extended. The extension time in Amazon is between 15 and 30 minutes. The triggering period in Yahoo Auction Japan is 5 minutes and auctions are extended by 5 minutes each time.

Some of the issues with the aforementioned auction formats include:

- There is no justification for why these times are chosen. That is, both the triggering period and the amount of time for the timeout period is not explained or supported by any form of publically disclosed information/research;
- Auctions can continue indefinitely as there is no cap on the number of timeout extensions permitted. This can frustrate bidders who think that they've missed the end of the auction only to realize that the auction has continued well beyond the actual closing time. Also this is may be unsuitable for certain types of goods which are transient in that their value depends on a timely sale;
- There is no incentive to not snipe within the provisional period; and
- There is no real disclosure of exactly how the underlying algorithm works.

Each of the aforementioned formats can be considered as 'set', whereas our proposed format is 'variable'. As our proposal makes decisions that 'varies' its behavior, it ensures that an auction cannot continue indefinitely by bringing it to a finish as bidding slows. We also enforce a maximum timeout limit. Short of undertaking any rigorous economic analysis, our proposal entices bidders to bid immediately by making random decisions and not disclosing the exact ending times once an extension is granted. Furthermore, our approach is modeled on the results of auction analysis to deduce an optimal provisional and triggering time. Finally, the underlying algorithm is completely public and open to scrutiny.

5. Conclusions

Bid sniping is the most dominant strategy for winning in online auctions. However, sniping has many undesirable consequences that disadvantage the seller and other bidders. These problems include diminished revenue for the seller, disgruntled bidders, and amplification of the winner's curse. Furthermore, online auctions are reduced to a hybrid sealed bid style auction, in which the effectiveness is difficult to gauge. Studies have shown that open bid ascending auctions produce higher average revenue compared to sealed auctions. Instead, online auctioneers should offer a range of auction styles and mechanisms which suit a particular market. The outcome of an auction should not depend on how fast someone can type in a bid or the speed of a bidder's Internet connection [Bapna 2003].

This paper presented a new online auction format for neutralizing the effect of bid sniping. The proposed system centers on forcing online auctions to function more like a traditional English auction where new bids prolong the auction's life. This behavior can be instilled into online auctions by allowing time-out extensions that lengthen the auction's termination time provided new bids continue to be made. Extending the auction's termination time in response to bidder activity gives other bidders the time to react in the presence of bid snipers.

By randomizing and not disclosing the exact amount of time for the extension, bidders are forced into bidding their true valuations immediately otherwise they risk not being included in the auction (as the auction terminates). This forces bid snipers to play by the same rules as everyone else as there is no further advantage to sniping. To further neutralize snipers, a double random non-deterministic approach to the maximum extension time can be chosen (for each auction) to make it difficult for snipers to gain any advantage by inspecting the algorithm.

When analyzing the behavior of bidders in commercial online auctions, we discovered that auction duration does not significantly affect bidding behavior. We also deduced from this behavior that the final 5 minutes of an auction would be the best time to trigger an extension. To ensure an auction doesn't continue indefinitely, our format includes mechanisms to limit the number of extensions granted. Furthermore, it can examine bid volume, the time bids are placed and also how far into the provisional period the auction is, in order to determine the optimal strategy for extending or terminating the auction.

Our proposed scheme is different to any "basic" auto exceed feature that is being used by existing commercial auctioneers. Firstly, it ensures that an auction cannot continue indefinitely by bringing it to a finish as bidding slows, enforcing maximum timeout limits, making random decisions and not disclosing exact ending times in order to entice bidders into bidding immediately. We have used the results of analysis to deduce an optimal provisional and triggering time. The underlying algorithm is completely public. At this point, we make no claims as to whether a complex closing mechanism will provide a better outcome for the seller and/or bidders compared to a simpler format – this will need to be formally verified against a range of criteria (e.g., economic theory, usability, algorithmic complexity, etc.).

Future work involves implementing the proposed auction format and running a series of auction simulations to examine its affect on sniping behavior (refer to [Trevathan et al. 2011] for details on how this would be achieved). This will allow for empirical verification for the proposed method's effectiveness against other counter-sniping mechanisms. Additionally, it would be intuitive to gather and analyze data from existing commercial auctioneers that implement a basic timeout extension approach and compare this against the performance of our proposed strategy. Furthermore, as much information is undisclosed, there must be a mechanism whereby the auctioneer's actions can be verified after the auction to ensure fairness (e.g., the auctioneer cheats by closing the auction in a manner that is inconsistent with the rules). Finally, it would be intuitive to examine the effect of the proposed auction format on shill bidding (artificial price inflation through spurious bidding) to see whether it exacerbates or reduces the problem (see [Trevathan and Read 2008]).

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