

From SIAM News, Volume 36, Number 2, March 2003

## Sold to the Latest Bidder

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Anyone who has bid in more than a handful of eBay online auctions has probably run into the phenomenon called "sniping," in which bidders place their bids in the last few seconds of an auction, leaving rivals no time to respond. To bidders who have had coveted items snatched away during the final ticks of the auction clock, snipers are predatory monsters who take unfair advantage of the auction rules. To snipers themselves, last-minute bidding is a legal, perfectly fair way to play the game, one that's open to all the players.

Since 1995, when eBay was founded, bidders have turned sniping into an art, opening eBay in several Internet browser windows simultaneously and synchronizing their computer clocks with eBay's to get their bids in right under the wire. Some companies even market sniping software that places last-moment bids automatically. Sniping is not risk-free: Because of the density of Internet traffic, bids placed within the last few seconds of an auction sometimes don't make it through in time. eBay's Web site recommends that people refrain from sniping, but people nevertheless seem to do it all the time. The prevalence of sniping, despite its risk, made economists Alvin Roth of Harvard University and Axel Ockenfels of the University of Magdeburg in Germany wonder whether eBay's advice is sound. Is sniping foolhardy, or is it in fact a rational response to the way the auction is structured?

Roth and Ockenfels decided to compare bidding strategies on eBay and another online auction, run by Amazon, which boasts that its rules are sniper-proof. The researchers found that the best strategies on Amazon don't involve late bidding, but that bidders on eBay have substantial strategic reasons to snipe, whether they're bidding against a seasoned eBay bidder or a novice. Field data gathered by Roth and Ockenfels from actual eBay and Amazon auctions support the idea that eBay snipers are not simply procrastinating but do indeed bid late for strategic reasons. The team published its findings in September in the American Economic Review. Up to now, researchers studying eBay tended to regard sniping as irrational. "Mostly, people thought of late bidding as an error," Roth says. "I think it's not."

### The Mechanics of Online Auctions

In a typical eBay auction, bidding runs for a specified amount of time, often a week; at every point during the auction, potential bidders can learn what the current high bid is and who has placed it. A bidder is free to place as many bids as he pleases during the auction, or to use eBay's proxy service to bid on his behalf. In proxy bidding, a bidder simply specifies the highest price he is willing to pay. The proxy system places an initial bid just high enough to beat the current high bid, after which it raises the bid by a small increment whenever someone else bids on the item, until the price goes above the bidder's maximum.

A bidder who uses eBay's proxy system can never fall prey to a sniper. Because the proxy system places bids almost instantaneously, even when a sniper bids in the last seconds of an auction, there is time for the proxy to outbid him. Snipers, incidentally, use the proxy system themselves—they just wait until the last moment before launching it.

Amazon auctions have a similar structure, except for the closing rule: Any time someone places a bid within 10 minutes of the time the auction is supposed to close, the auction is automatically extended 10 more minutes. The auction ends only when 10 minutes have elapsed with no bids.

### Why Snipe?

One obvious reason to snipe on eBay is to avoid getting into bidding wars with inexperienced bidders who do not use the proxy system and who bid repeatedly when higher bids come in, treating the auction like the familiar "going, going, gone" auctions used in art houses like Sotheby's and Christie's. If you place an early bid using the proxy system, such a bidder will top your bid, after which your proxy will top her bid, she'll top your bid, and so on, until one of you has been pushed up to your maximum. If you place your bid at the last moment, by contrast, that bidder has no time to react and push up the price. For the same reason, sniping is also a good defense against "shilling," in which the seller enters the auction, under a false name, to drive up prices, in strict violation of eBay's rules. On Amazon, sniping will be ineffective against either a naive bidder or a seller who shills, since late bids are always followed by extensions of the auction.

Sniping is the best strategy against inexperienced bidders, but is it a good strategy against experienced bidders, who use the proxy system or perhaps snipe themselves? To investigate how a collection of purely rational players will behave in eBay and Amazon auctions, Roth and Ockenfels looked for strategies that produce a Nash equilibrium—that is, strategy choices under which no player could improve his lot by unilaterally switching to a different strategy.

### Vickrey Auctions

Both eBay and Amazon auctions have some features of the "going, going, gone" auction, known as the English auction. In 1961, economist William Vickrey analyzed strategic behavior in English auctions for the case in which bidders' values for the item are independent of each other—what economists call the "private values" setting. An example is an art auction in which the bidders want to buy a work of art simply because they like it or it has sentimental value for them; finding out how much other bidders value it will not change how much they value it themselves (although it could change their bidding strategies).

An English auction continues only until the second-highest bidder drops out: the winner pays that bidder's high price plus a tiny increment. Vickrey realized that the English auction is strategically equivalent to an auction he invented, called the "sealed second-price auction." In a second-price auction, each bidder submits a single sealed bid, and the winner pays only as much as the second-highest bid. An eBay or Amazon auction in which all the bidders use the proxy system effectively turns into a second-price auction: Each bidder submits a single sealed bid (his maximum), and the proxies then bid each other up until they reach the maximum of the second-highest bidder, at which point the highest bidder wins, again at a slightly higher price.

In a second-price auction, bidders have an exceptionally simple best strategy: They should simply bid the highest price they are willing to pay for the item. To see this, imagine that you are bidding for an item for which you would be willing to pay up to \$200, and suppose you bid less than that—maybe \$150. If the highest rival bid is even less, say \$125, then you win and pay \$125, but the same thing would have happened if you had bid your true value of \$200. If the highest rival bid is more than \$200, you lose the auction in any case. But if the highest rival bid is between \$150 and \$200—say \$175—then if you bid \$150 you lose the auction, whereas if you had bid your true value you would have won and paid \$175, a desirable outcome. Bidding lower than your true value can make you lose auctions you would have preferred to win; similarly, bidding higher than your true value can make you win auctions you would have preferred to lose.

In a second-price auction, bidding honestly is what game theorists call a "dominant" strategy: It is the best thing to do, no matter what strategies the other bidders adopt. In the same way, the best strategy in an open English auction is to keep bidding until the high bid reaches your value for the item, and then drop out.

### Online Auction Strategies

For eBay auctions, it's not hard to see that there is no dominant strategy. Suppose, for instance, you are bidding against someone whose strategy is to place a low bid early in the auction, then to top any other bids that come in, until his maximum is reached. Sniping is clearly the best approach against such a bidder. But suppose instead that you are the only bidder. In

that case, it's better to bid early, since if you snipe there is always a small chance that your bid will not make it through before the auction closes. Because your optimal strategy depends on what your opponents do, no dominant strategy exists for eBay auctions. A similar argument can be constructed for Amazon auctions by considering slightly different opponent strategies.

Although eBay and Amazon have no dominant equilibria, they must have Nash equilibria: Nash proved in 1949 that any game with a finite set of pure strategies has at least one equilibrium. (A pure strategy makes no use of random decisions, like tossing a coin, to decide between two possible moves.) And, in fact, one equilibrium in eBay and Amazon auctions is clear: If all the bidders use proxy bidding, no one has an incentive to switch to another strategy.

Roth and Ockenfels showed that for Amazon auctions, proxy bidding is the only equilibrium that is rational at every moment of the auction, given what the bidders know at the time. But for eBay auctions, they showed that there is a second equilibrium, in which the bidders use sniping to collude implicitly, netting themselves a cheaper selling price than if they had used the proxy system.

Suppose all the players adopt the following strategy: In response to any bid that comes in, the players immediately place bids, using the proxy system; otherwise, they snipe. It's not hard to show that this is a Nash equilibrium. Suppose a player adopts the following strategy: If any bid comes in during the auction, he immediately places a bid, using the proxy system; otherwise, he snipes. It's not hard to show that if all players follow this strategy, the result is a Nash equilibrium. In this scenario, the players all end up sniping, since none will choose to be the first to place an early bid.

Because of the small probability that a sniper's bid won't be placed in time, the number of bids that get through will usually be smaller than if the bidders had all placed early proxy bids. The smaller bidding pool means that the selling price will be lower, on average, than in the proxy-bidding equilibrium.

In the sniping equilibrium, Roth and Ockenfels observe, the players are effectively colluding to keep the price down, even though they make no explicit agreement ahead of time. Bidders could well be colluding in this way without realizing what they are doing, Roth suggests—they might simply give sniping a try, win the auction at a low price, and conclude that sniping is a good technique. "We're not proposing that this is cleverly thought through," he says. "There's a whole strain now in economic theory on reinforcement learning—the idea being that people do something, and if it works then they keep on doing it."

Many eBay and Amazon auctions have an additional twist. Unlike the auctions Vickrey studied, bidders' values for the item being sold may not be independent of each other—producing what economists call the "common value" setting. When an item has an intrinsic value that is unknown to the bidders, for example, knowing that another bidder values the item highly may make you value it more highly yourself, especially if that other bidder is known to have special expertise. In both eBay and Amazon auctions, bidders have ratings that indicate the extent of their bidding experience. So it is possible for bidders to look at the bidding behavior of the most experienced bidders and adjust their values accordingly.

In such situations, Roth and Ockenfels observe, some bidders have yet another reason to snipe. Suppose an antique chest is being auctioned, and two bidders are vying for it; one is an expert who knows the chest is genuine and is willing to pay \$400 for it, and the other is a dealer who would be willing to pay \$450 for the chest but is not sure whether it is authentic. If the expert bids early in the auction, he has effectively authenticated the item for the dealer, who will then outbid him. But if he snipes, he protects his valuable information until the last moment of the auction. In Amazon auctions, by contrast, the expert doesn't have the option of keeping his cards close to his belt, and the dealer is guaranteed to win.

### Bidding in Actual Auctions

Sniping on eBay is good strategic behavior in both common-value and private-value settings, and against both naive and experienced bidders. But buyers might bid late rather than early for other, nonstrategic reasons. Some bidders procrastinate, or dislike placing bids that are left hanging for a week. Others may try to buy the same item in more than one auction, and wait for the outcome of one auction before bidding in another. What's more, search engines present the auctions that are closing soon at the top of their lists; people might bid in auctions that are about to close simply because those are the first ones they find. If these nonstrategic reasons are in fact the predominant causes of late bidding, there should be as much late bidding on Amazon as on eBay.

To test whether strategic or nonstrategic motives are the driving force behind late bidding, Roth and Ockenfels turned to the empirical evidence of the auctions themselves. As a warm-up, they bid themselves in several eBay auctions. "I now have a fairly large collection of Bronze Age weapons, if anyone wants them," Roth says. When he won, it was usually by sniping.

Roth and Ockenfels looked at the timing of the winning bids in 480 eBay and Amazon auctions, half of them for computer equipment and half for antiques. They found dramatically more late bidding on eBay than on Amazon, suggesting that strategic reasons are indeed behind the late bidding on eBay. What's more, Roth and Ockenfels found that the more experienced an eBay bidder was, the more likely she was to snipe. On Amazon, the opposite was true.

They also observed more sniping in the antiques auctions than in the computer auctions, which makes sense if bidders are bidding late for strategic reasons. It's far easier to estimate the value of a piece of computer equipment than of an antique, which gives experts a distinct edge in an antiques auction. Thus, experts have even more reason to snipe in an antiques auction than in a computer auction.

Late bidding in online auctions is not an isolated phenomenon. In the mid-1990s, when the FCC was designing the rules for its hugely successful spectrum auctions, one of the main concerns of auction theorists was to prevent bidders from lying low until other bidders had shown their hands and then bidding at the last moment. The spectrum auctions, like eBay and Amazon, were planned to be open English auctions. To avoid late bidding, the FCC divided the bidding into rounds, and required that a bidder place bids in each round if he wanted to stay in the action. Roth and Ockenfels's study suggests that a closing rule like Amazon's is another way to deter late bidding.

eBay and Amazon auctions contain an important lesson for auction designers, Roth and Ockenfels say. "We need to be alert to the fact that small design differences can elicit substantial differences in behavior," they write. When it comes to auctions, the devil is in the details.

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