Market Design for CAT

Achal Augustine and Amruth Puttappa

December 2006

Abstract

Market design is concerned with the creation of an arena where buyers and sellers can meet and a specification of the rules by which they execute trades. The challenges of the market design is to develop an efficient market and at the same time maximize the revenue of the market maker. This paper discusses the design and features of specialist Avalon which won the Fall 2006 CAT class tournament of Agent Based E-commerce course at UT-Austin. We also present controlled experiments and tournament results demonstrating salient features of Avalon.

Introduction

Electronic market design is a new field of research that builds on theories from various established fields. It includes creation of rules for trading interaction, in particular for auction, that lead to economically desired allocations of items and payments. The classic Trading-Agent Competition (TAC Classic) and the supply chain secnario (TAC SCM) were motivated by the desire to develop automated strategies for buyer and seller software agent in marketplaces. In contrast trading agents are provided by the organizers of CAT competition and participants of CAT design markets and compete against each other to attract traders to their markets. A CAT tournment was held in the Agent Based E-commerce class, Fall 2006 at UT-Austin. We describe our agent Avalon which uses two-phase strategy to win the tournament.

The layout the paper is as follows - Section 2 consists of a brief description of the game; Section 3 describes CAT strategies; Section 4 details the experiments and simulations that were performed; and finally, section 5 underlines the various conclusions that were reached.

Game Description

A CAT competition has *Trading agents* and *Specialist agents*, hereinafter referred to as *Traders* and *Specialists*. Traders include buyers and sellers. Traders transact business through specialists. In any game there are two kinds of traders, ZIP or GD [1, 3]. They register to a specific specialist at the start of each day and do business only in that specialist market. Specialists designed by five teams and a dummy zero-fee no-transaction participated in the tournament. Each game had between $50 - 200$ traders - $25 - 75\%$ of those were sellers and the rest, of course, buyers. There were $30 - 150$ days in each simulation and $3 - 10$ rounds per day. Specialists are mechanisms that enable Traders to execute their trade. Specialists can collect fees from the traders for offering the service. Specialists are described in detail in the following sections.

Specialist Strategies

The central challenge of this project was the design of the specialist paradigm. Parameters integral to the design of the specialist included charging policy, shout acceptance policy, clearing policy and pricing policy. These are discussed in detail in the following subsections. The specialist that we designed for this project was named Avalon. [1]

[1] Most of our work was conducted in the Avalon apartment complex in central Austin.

Charging Policy

Before describing Avalon's charging policy, a brief outline of the different kinds of fees will be appropriate. Specialists make profits when Traders transact at their markets by charging fees. The fee types are -

1. Registration fees, charged each day when a Trader registers.
2. Transaction fees, charged when buyer/sellers do a transaction.
3. Information fees, charged for requesting shout or transaction information.
4. Shout fees, charged when traders specify a bid/ask price.

For the purposes of charging, Avalon divides each game into two separate phases - the market building phase and the offload phase.

Market Building Phase

In the market building phase, Avalon tries to increase its market share by attracting traders.It continuously builds its reputation [5] among the traders, so that they stay longer in its market.

In order to obtain a viable strategy for the market building phase, we designed three different policies with which Avalon could attract traders.

1. Zero-price policy : In this the specialist charges zero price for all types of fees.
2. Fractionally-low price policy: On any given day, the specialist examines the prices offered by its competitors on the previous day. If it finds a lower price than its own, it offers a price fractionally lower than the previous day minimum price.
3. Exponentially-low price policy: This is similar to the previous policy except that the discount factor is exponential instead of fractional.

With game theoretical approach it can be show that *Zero-price policy* is a dominant strategy Nash equilibrium [4] in market building phase. Figure 1 shows a set of 10 experiments conducted with zero-price, fractionally-low and exponentially low-price specialists in market building phase, but having same policies in offload phase. The higher profit observed with the zero-price policy can be attributed to higher market capturing in the market building phase. Based on these results, we adopted the zero-price policy for *Avalon* .

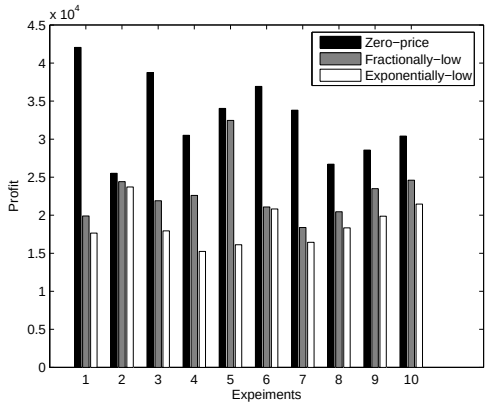

Figure 1: Experiments showing the profits of specialists, which are using Zero-price,fractionally-low and exponentially -low

Offload phase

By the end of market building phase, Avalon will have a substantial amount of traders. In the market building phase it makes zero profit to increase its market size and build a good reputation. The market size and the fees that it charges ensures that the specialist would make a substantial profit during the offload phase; moreover, its reputation establishes a low trader attrition rate. To maximize revenue at the end of offload phase the specialist should have offloaded all of its traders or should be left with minimum number of traders.

Triggering

Triggering determines the point of transition between the market building phase and the offload phase. The length of market building and offload phases determine the entire profit of the mechanism. If the market building phase is too long then the specialist will have a large number of traders, but due to a short offload phase it cannot realize much profit before the end of the game. On the contrary, if the market building phase is too small, then traders will be offloaded before its market reaches a substantial size.

In order to determine a suitable transition point, Avalon monitors the following parameters are from game to game -

- *End trader fraction*, the fraction of reasonable market size left with it at the end of the game, where reasonable market size is ratio of number of traders to number of specialists.

- *Trigger fraction*, the fraction of game length for which it executes market building phase
- *Game status*, either true or false indicating Avalon's win or lose in the current game.

End Trader fraction is computed as,

$$EndTraderfraction = \left(\frac{Avalon's\,EndTraders}{Number\,of\,Traders/Number\,of\,Specialists}\right)$$

The end trader fraction indicates the effect of trigger fraction on the game. If the end trader fraction is too low, that indicates that Avalon triggered too early, and vice-versa. An upper and lower bound is defined for the end trader fraction; the trigger fraction for each game changes according to the end trader fraction in the previous game. For example, if Avalon lost the previous game and *End Trader fraction* is greater than the maximum trader fraction then it decreases the *Trigger fraction* by δ. The algorithm executed is show in Table 1. Where Max Trader fraction is the maximum limit of profitable end trader fraction and Min trader fraction is the minimum limit of profitable end trader fraction

Table 1: Algorithm to compute Trigger fraction

if *gamewon*:True
then do nothing
else *gamewon*:false
then if *End Trader fraction* > Max Trader fraction
do *Trigger fraction* = *Trigger fraction* $-\ \delta$
else if *End Trader fraction* < Min Trader fraction
do *Trigger fraction* = *Trigger fraction* $+\ \delta$
else
then do Mean Trader fraction $=\frac{(MaxTraderfraction+MinTraderfraction)}{2}$
if *End Trader fraction* > Mean Trader fraction
do *Trigger fraction* = *Trigger fraction* $-\ \frac{\delta}{2}$
else do *Trigger fraction* = *Trigger fraction* $+\ \frac{\delta}{2}$

Shout Acceptance Policy

Shout accepting policy decides which shouts to be accepted. We considered the following two policies.

Quote Beating Policy

In this policy new bids/ask are accepted only if it beats the current bid/ask price. Specifically a new bid is accepted only if it exceeds the current highest bid and ask is accepted if it falls below the current lowest ask price. This policy emulates the NYSE structure. In this the equilibrium price is reached relatively sooner.

Accept All Policy

In this policy, bid/asks are accepted irrespective of the price or the bidding position. Traders are given the choice to place any shout they want. Figure 2 shows a comparison of revenue generated by two versions of Avalon one using Quote Beating policy and the other using Accept All policy against same set of traders and specialists with all other policies kept same.

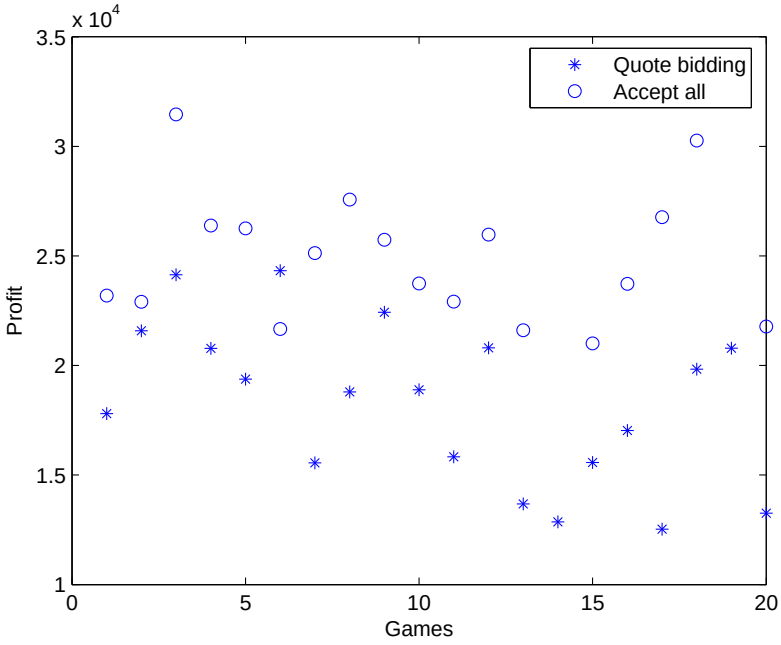

Figure 2: Quote beating policy vs Accept all policy

As the graph shows Accept All policy generated more revenues for the specialist and we decided to use the accept all policy. It was seen that the traders were not sensitive to the speed with which the market converged to an equilibrium.

Clearing Policy

Clearing policy decides when the auction makes allocations. It consists of clearing time, closing conditions, matching functions and tie breaker policies of an auction. The clearing policy didn't show any significant impact on the trader preferences and we used the default continuum between CDA and CH.

Pricing Policy

The pricing policy decides at what price the transaction should take place, once the bid price goes above the ask price. Avalon used a pricing policy which favored large quantity bids. The transaction price is set to a price which is proportionally closer to the shout with lower quantity.

$$
\begin{array}{l}
if(bidQuantity < askQuantity) \\
\quad quantityRatio = bidQuantity/askQuantity \\
transactionPrice \\
= bidPrice - (quantityRatio * .5 * (bidPrice - askPrice)) \\
\text{else} \\
quantityRatio = askQuantity/bidQuantity \\
transactionPrice \\
= askPrice + (quantityRatio * .5 * (bidPrice - askPrice))
\end{array}
$$

Since in the current CAT format the traders has a constant bid and ask quantity of one, the pricing policy didn't effect the revenues significantly. When traders are able to bid different quantities, our pricing policy would attract large bidders and encourage traders to bid for larger quantities.

Simulations and Tournament Results

For simulations we used game length of 90 days and trader population of 150, consisting of ZIP and GD traders. The traders used epsilon greedy or softmax as their market selection strategy with epsilon values in the range of 0.05 - 0.3.

Avalon vs Leachy Specialist

We designed the Leachy specialist to try out the possibility of using a specialist who undercuts the highest fees to attract traders from the specialist charging highest fees and at the same time generate high revenue, unlike Avalon which either attracted traders in the market building phase or generated revenues in the offload phase. Any given time the Leachy specialist offers the second highest price to undercut the specialist with the highest

fees and a reasonable market share, where reasonable market share is 0.5 times the ratio of number of traders to number of specialists. The Figure. 3 shows revenue of Avalon and Leachy for 10 games. Avalon consistently outperformed Leachy, because although Leachy was undercutting the highest charging specialist it consistently lost its traders to specialists who were charging lesser than Leachy. While Avalon succesfully attracted traders in the market building phase and generated maximum possible revenue in the offloading phase. This gave us an important result that a specialist cannot attract traders with second highest fees and the moment the specialist charges any price above the lowest fees it tends to loose the traders. This motivated us to use two phase strategy of attracting traders with zero- fees and offloading them with highest possible fees.

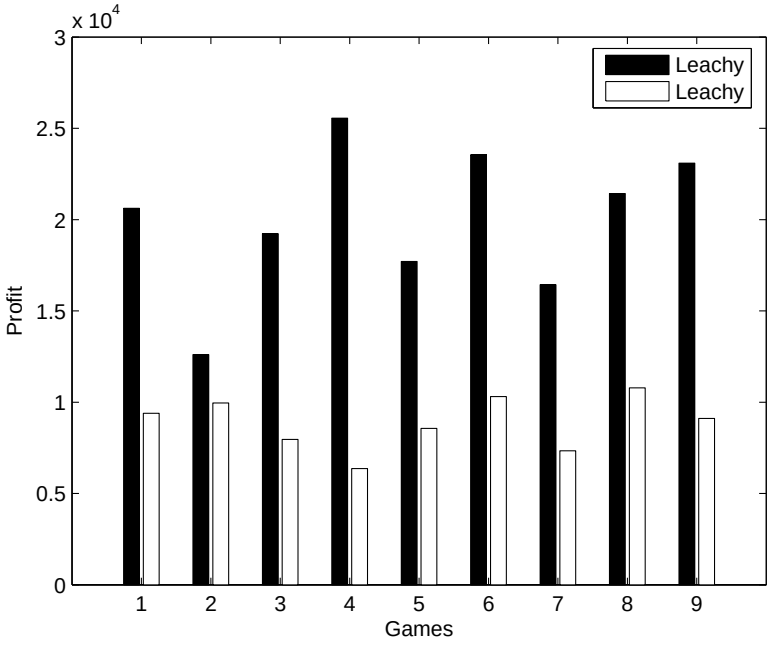

Figure 3: Avalon vs Leachy specialist

Marketpeaker Specialist

Marketpeaker specialist was designed to investigate the possibility of using trigger strategy multiple number of times during the course of a game. Marketpeaker specialist offers zero-fees till it finds that it cannot attract any more traders even with the zero-fees. This saturation point where zero-fees stops attracting traders or the growth in number of traders is negligible is called the market peaking point. After the market peak, the Marketpeaker

specialist offloads all the traders from its market by charging the maximum possible fees. This offloading is continued till the specialist finds that the current market size has become negligible and the specialist goes back to the market-building phase with zero-fees. The Figure 4 shows the number of traders in both Marketpeaker and Avalon and Figure 5 indicates the revenue of the same specialists. It is observed both Marketpeaker and Avalon attract same number of traders in their initial market building phases but in the second market building phase of Marketpeaker, it fails to rebuild its market base lost during the offloading phase because there are other specialists who are already offering zero-fees. As a result of this Marketpeaker loses substantial revenue in the second market building phase without attracting many traders. This makes multiple use of trigger policy during the course of a single game ineffective.

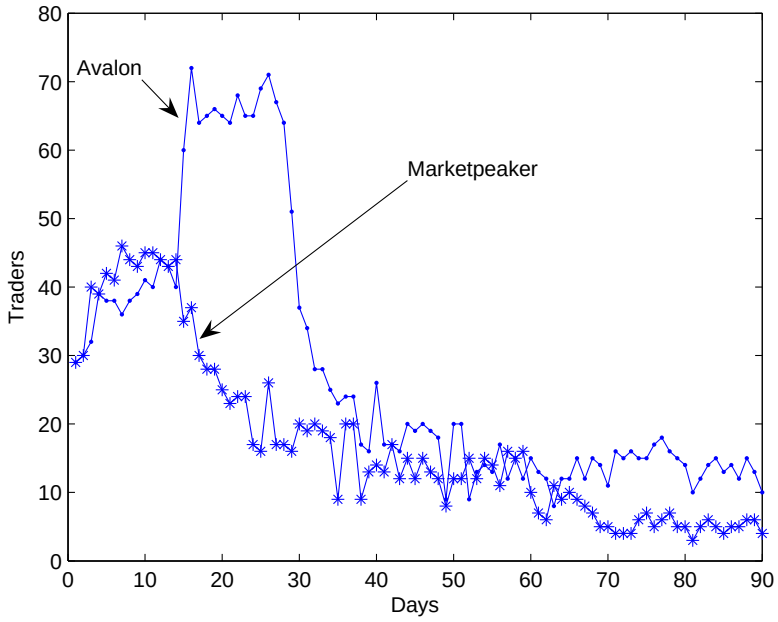

Figure 4: Trader Distribution of Avalon and Marketpeaker

Tournament Results

Figure 6 shows the trader distribution among specialists in 81 day long games of the tournament. Avalon successfully captured bulk of the traders in its market building phase and was able to offload them towards the end of the game. SHMart specialist which used an average market fees policy

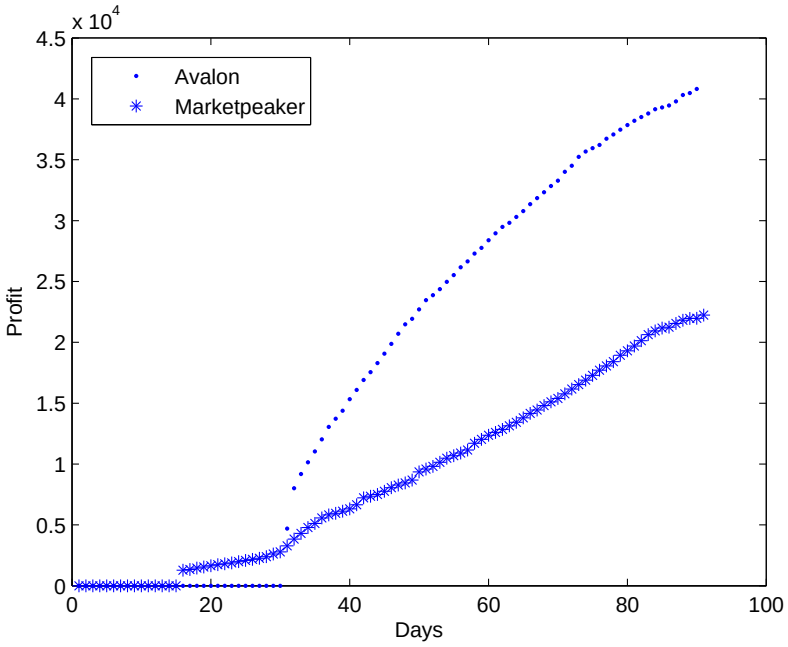

Figure 5: Profit Distribution of Avalon and Marketpeaker

was unable to maintain the initial number of traders and continued to lose the traders during the game.

Figure 7 shows the profit distribution among specialists in 81 day long games of the tournament. Avalon was successful in realizing huge profit in the offloading phase using its high market base and the high fees charged during this phase. Akumen which was charging the second highest fees in the offloading phase was not able to realize as much revenue as Avalon but at the same time lost traders to specialist charging lower fees.

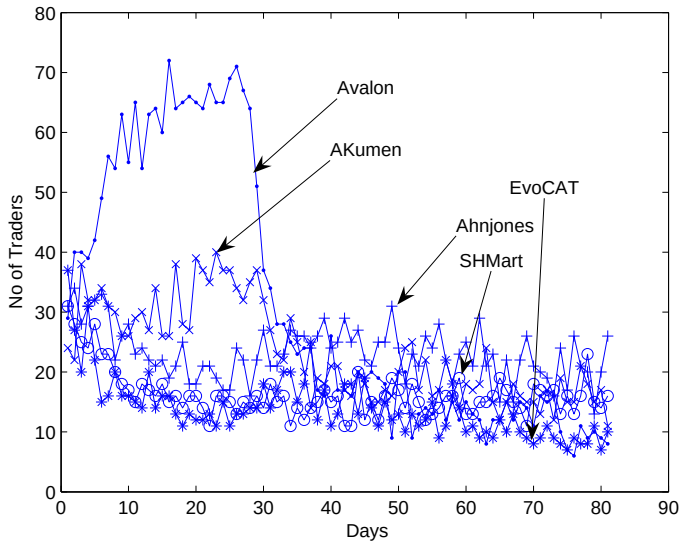

Figure 6: Trader Distribution of Specialists in the tournament

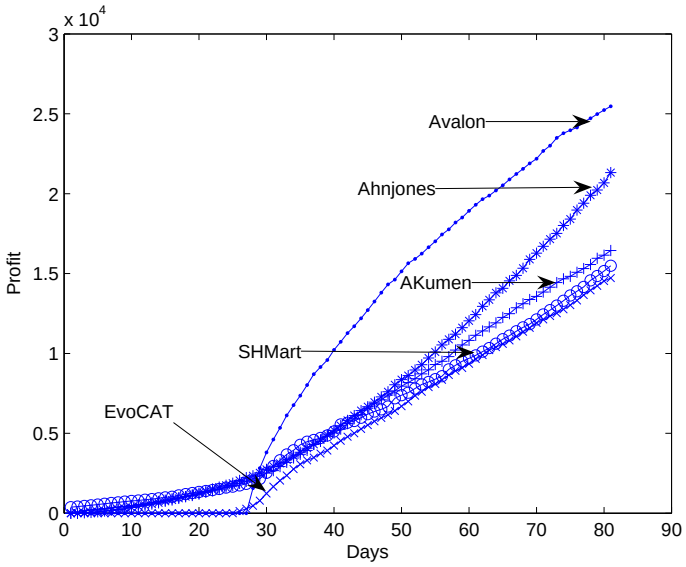

Figure 7: Profit Distribution of Specialists in the tournament

Conclusion

This report provides a number of insights into building specialists for CAT market design. Specifically, it details the design, implementation and evaluation of Avalon ,an agent that successfully participated and won class tour-

nament in Fall 2006 CAT competition at University of Texas at Austin. The experiments and the results of the tournament shows that the cat game in the current format can be won with the simple strategy of attracting the traders with zero-fees in the market building phase and charging maximum possible fees in the offloading phase. The trigger day for switching between the phases can be tuned from game to game. It was also seen that second highest fees strategy doesn't attract traders neither does it generate enough revenue to beat the Avalon strategy.

The CAT game could become more interesting and challenging if the specialists has a mechanism for participating in their own markets as market makers and possibly a meta-market for inter-specialist trades. In such a scenario the CAT game would no longer be a price war and specialist will have to develop complex methods for predicting the market price and trader movements. Specialist profit would also depend upon how efficiently they facilitate and participate in the markets. Current restriction of shout quantity of one is also limiting possibilities for trying out different pricing and clearing mechanisms. We hope to see a CAT tournament which addresses these issues.

Bibliography

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