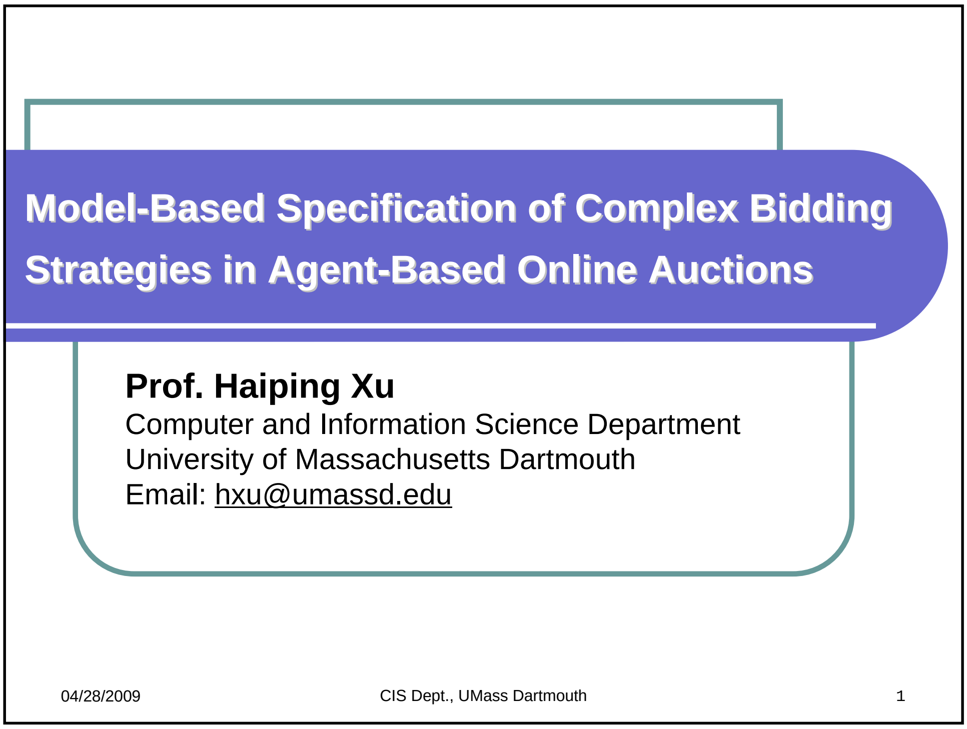

Model-Based Specification of Complex Bidding Strategies in Agent-Based Online Auctions

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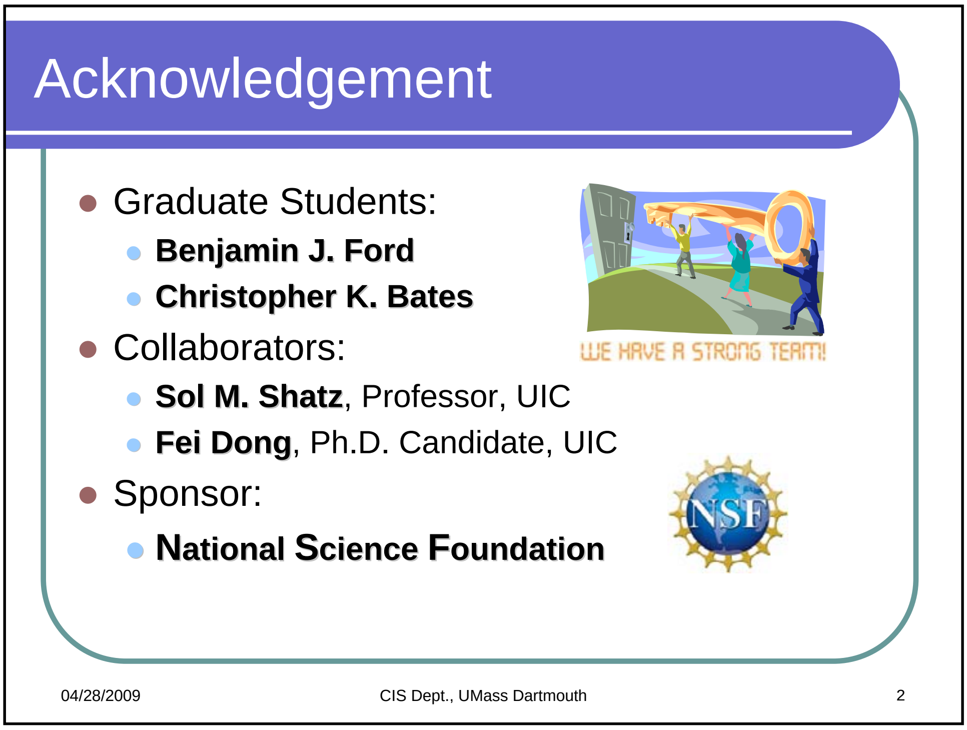

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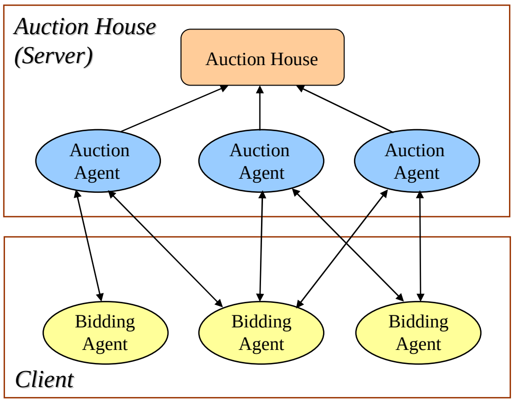
NSF

Online Auctions

- Different types of auctions
  - Increase-price auction (English auction)
  - Decrease-price auction (Dutch auction)
  - Second-price sealed-bid auction (Vickrey auction)
- English auction has become the most popular one in online auction houses (e.g., eBay).
- However, it is time-consuming for a human user to search and place bids on an auctioned item.
- There is a pressing need to introduce agent technology into online auction systems.

Agent-Based Online Auctions



Auction House (Server)

Auction House

Auction Agent

Auction Agent

Auction Agent

Bidding Agent

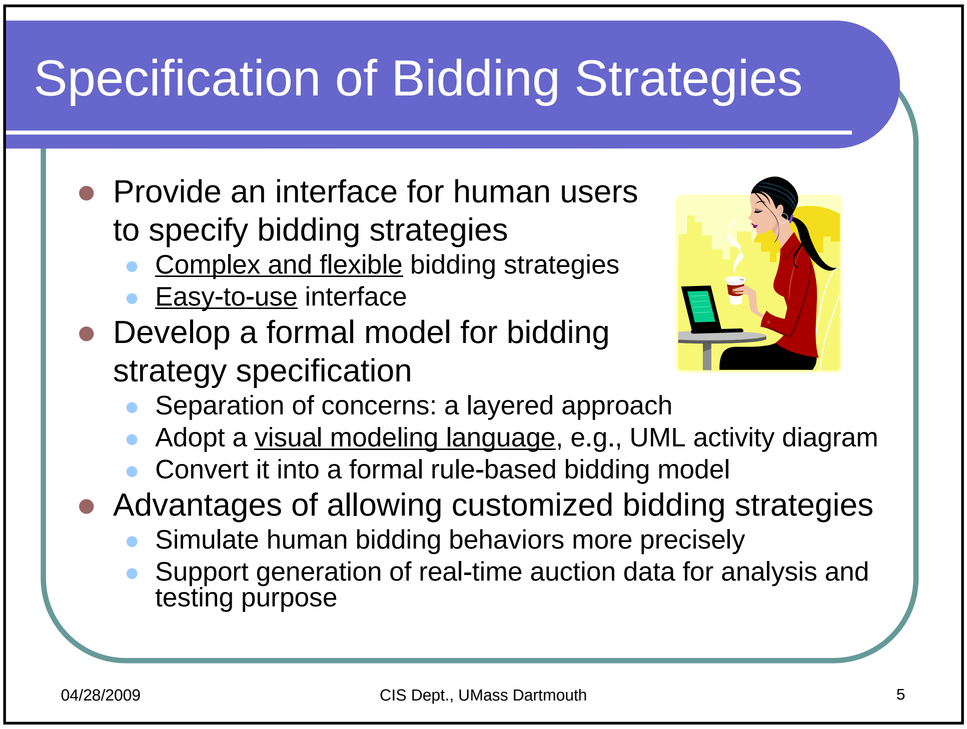
Bidding Agent

Bidding Agent

Client

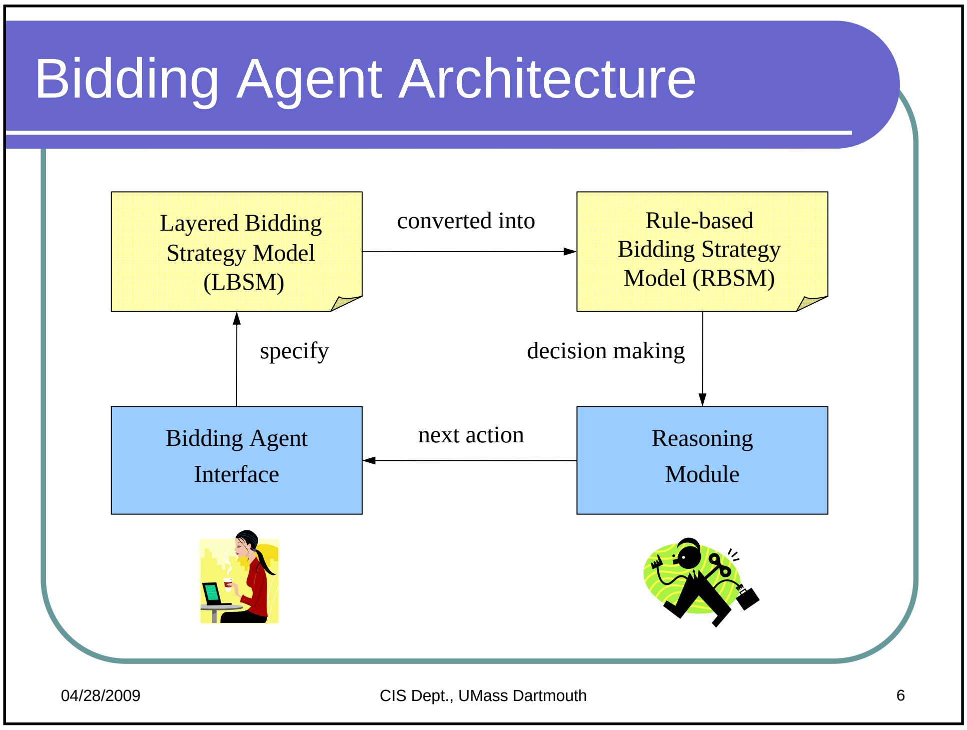
- It consists of an auction house and a number of clients.
- It is designed as a multi-agent system.
- The auction house is managed by auction house administrator.
- Agents at the client side work on behalf of human users.

Bidding agents can place bids on behalf of human users, and they are typically running on different machines.

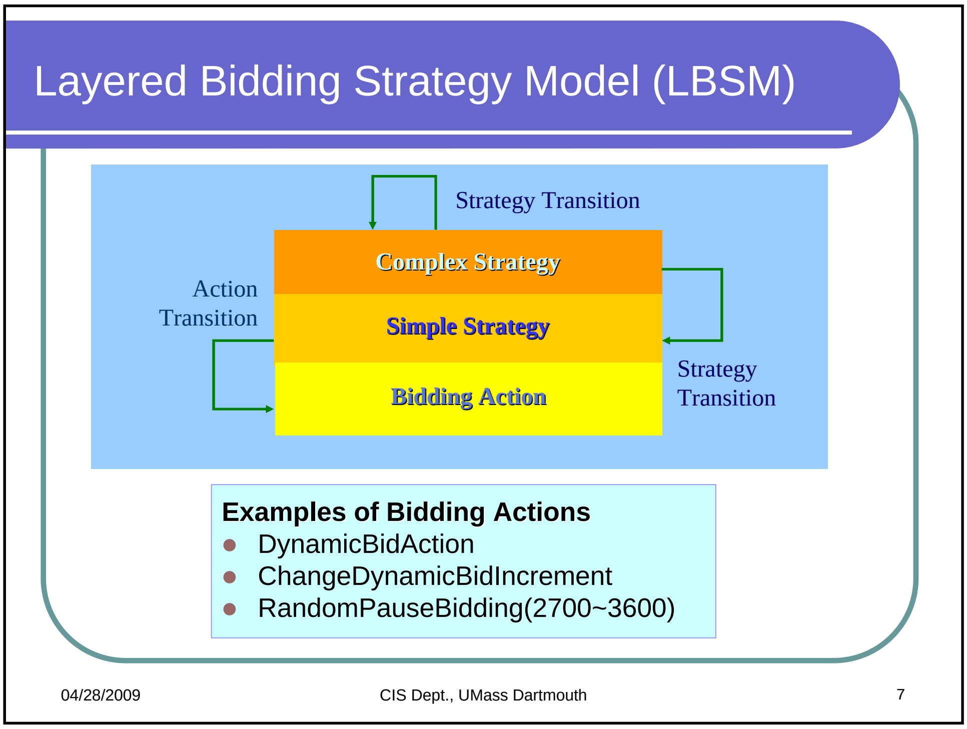


Specification of Bidding Strategies

- Provide an interface for human users to specify bidding strategies
  - Complex and flexible bidding strategies
  - Easy-to-use interface
- Develop a formal model for bidding strategy specification
  - Separation of concerns: a layered approach
  - Adopt a visual modeling language, e.g., UML activity diagram
  - Convert it into a formal rule-based bidding model
- Advantages of allowing customized bidding strategies
  - Simulate human bidding behaviors more precisely
  - Support generation of real-time auction data for analysis and testing purpose



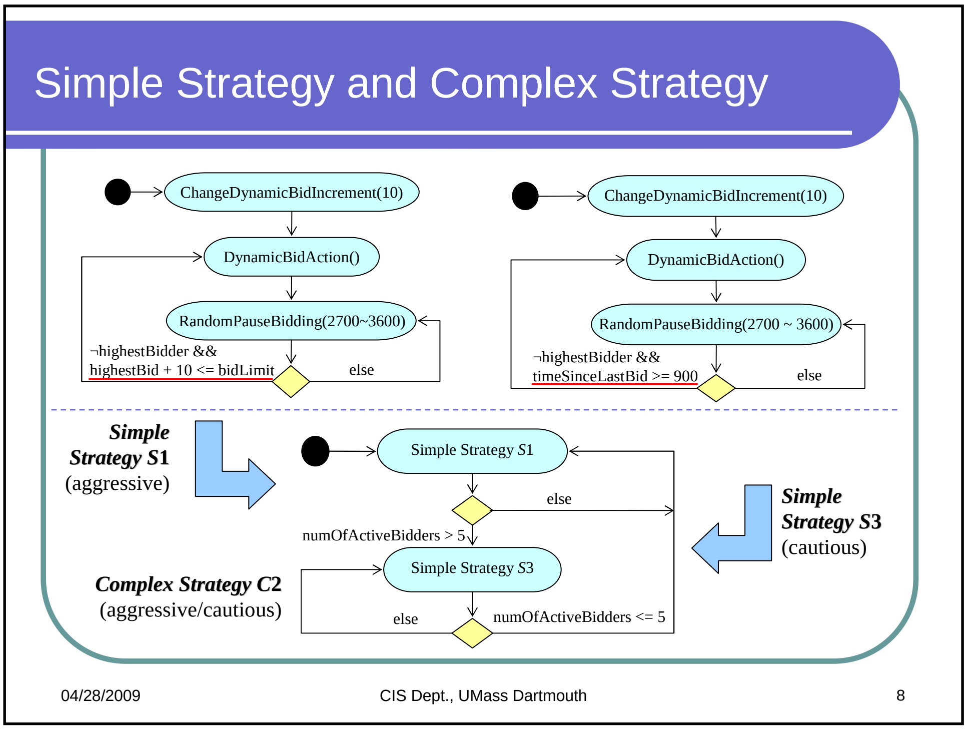
Bidding Agent Architecture



Layered Bidding Strategy Model (LBSM)

Examples of Bidding Actions

- DynamicBidAction
- ChangeDynamicBidIncrement
- RandomPauseBidding(2700~3600)

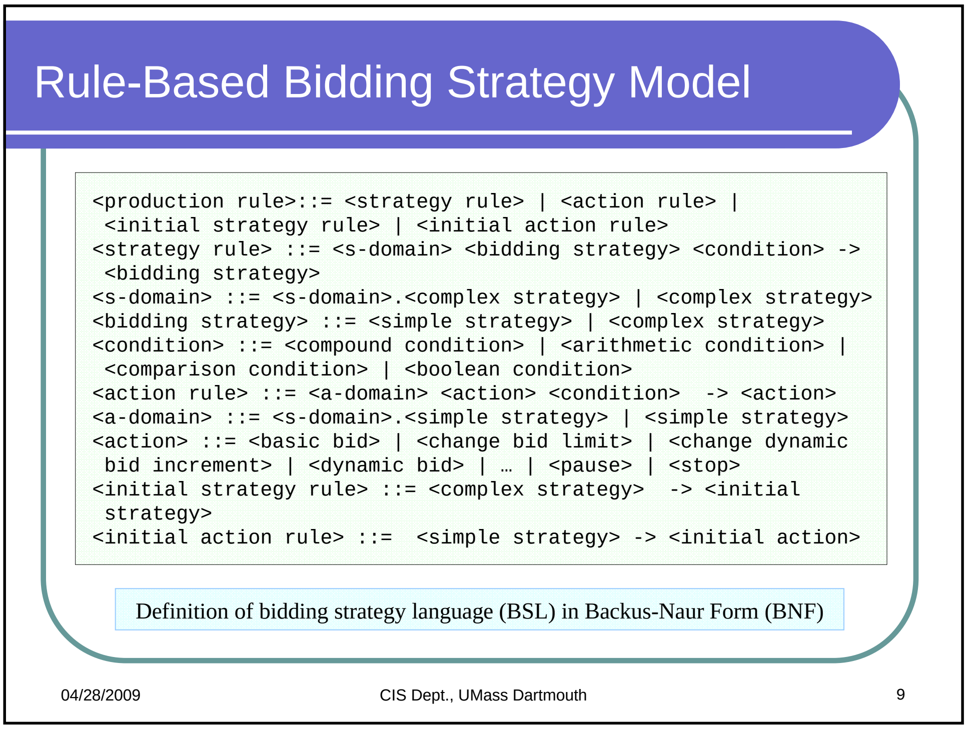


Simple Strategy and Complex Strategy

Simple Strategy S1 (aggressive)

Simple Strategy S3 (cautious)

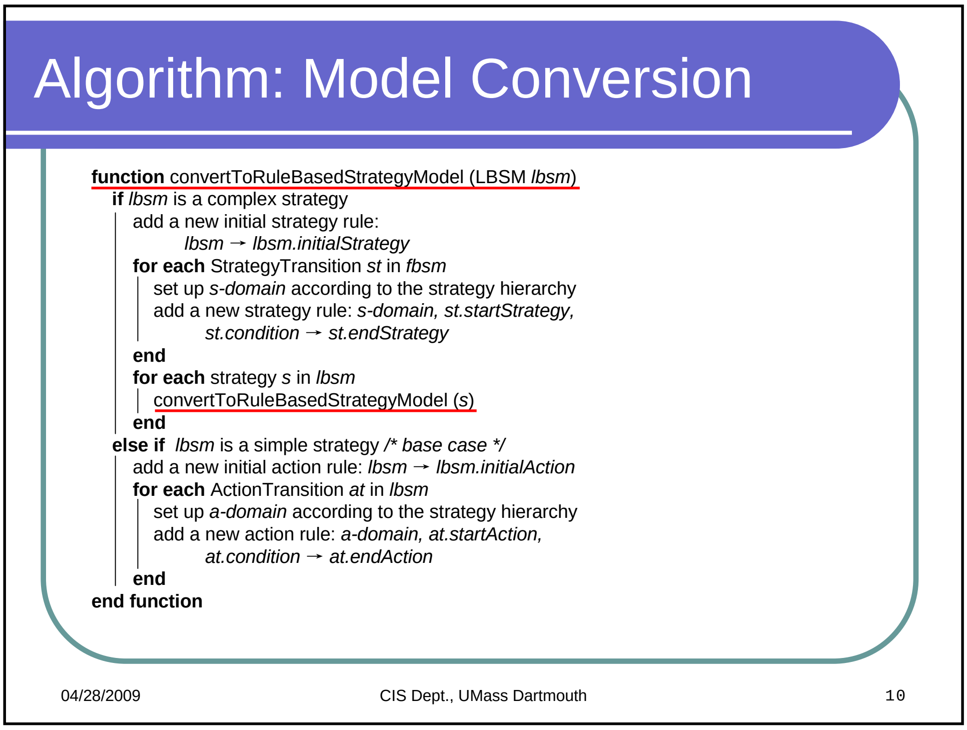
Complex Strategy C2 (aggressive/cautious)



Rule-Based Bidding Strategy Model

```
<production rule>::= <strategy rule> | <action rule> |
 <initial strategy rule> | <initial action rule>
<strategy rule> ::= <s-domain> <bidding strategy> <condition> ->
 <bidding strategy>
<s-domain> ::= <s-domain>.<complex strategy> | <complex strategy>
<bidding strategy> ::= <simple strategy> | <complex strategy>
<condition> ::= <compound condition> | <arithmetic condition> |
 <comparison condition> | <boolean condition>
<action rule> ::= <a-domain> <action> <condition>  -> <action>
<a-domain> ::= <s-domain>.<simple strategy> | <simple strategy>
<action> ::= <basic bid> | <change bid limit> | <change dynamic
 bid increment> | <dynamic bid> | … | <pause> | <stop>
<initial strategy rule> ::= <complex strategy>  -> <initial
 strategy>
<initial action rule> ::=  <simple strategy> -> <initial action>
```

Definition of bidding strategy language (BSL) in Backus-Naur Form (BNF)



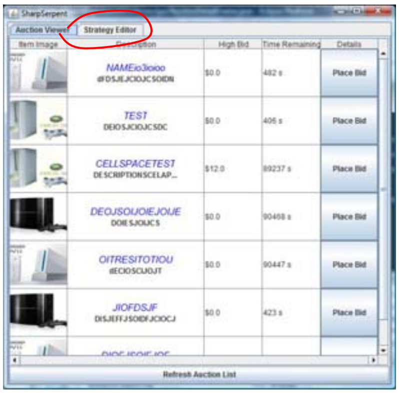
Algorithm: Model Conversion

```
function convertToRuleBasedStrategyModel (LBSM lbsm)
   if lbsm is a complex strategy
      add a new initial strategy rule:
              lbsm → lbsm.initialStrategy
      for each StrategyTransition st in fbsm
         set up s-domain according to the strategy hierarchy
         add a new strategy rule: s-domain, st.startStrategy,
                 st.condition → st.endStrategy
      end
      for each strategy s in lbsm
         convertToRuleBasedStrategyModel (s)
      end
   else if  lbsm is a simple strategy /* base case */
      add a new initial action rule: lbsm → lbsm.initialAction
      for each ActionTransition at in lbsm
         set up a-domain according to the strategy hierarchy
         add a new action rule: a-domain, at.startAction,
                 at.condition → at.endAction
      end
end function
```

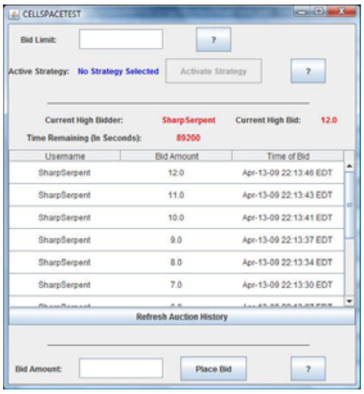
Algorithm: Reasoning Engine

```
function Action findNextAction
    (Domain domain, Action currentAction)
  if currentAction == null
    if domain is a ComplexStrategy
      Search for initial strategy rule isr for
      domain that leads to initial strategy is
      return findNextAction (is, null)
    else if domain is a SimpleStrategy
      Search for initial action rule iar for
      domain that leads to initial action ia
      return ia
  else if currentAction != null
    Remove and process the first element
    fe of domain, and let the remaining
    domain be r-domain
    if fe is a ComplexStrategy
      /* strategy transition */
      Retrieve all strategy rules for the first
      element of r-domain- and store them
      in a list
      while the list is not empty
        Remove and process strategy rule sr at list
        head
        if the condition for sr is true
          Let s be the conclusion part of sr
          return findNextAction (s, null)
      return findNextAction (r-domain, currentAction)
    else if fe is a SimpleStrategy
      /* action transition */
      Retrieve all action rules for the currentAction
      and store them in a list
      while the list is not empty
        Remove and process action rule ar at list
        head
        if the condition for ar is true
          return the conclusion part of ar
      return currentAction
end function
```

Bidding Agent Interface



Item Image	Description	High Bid	Time Remaining	Details
	NAMEio3ioioo dFDSJEJCIOJCSOIDN	$0.0	482 s	Place Bid
	TEST DEIOSJCIOJCSDC	$0.0	405 s	Place Bid
	CELLSPACETEST DESCRIPTIONSCELAP...	$12.0	89237 s	Place Bid
	DEOJSOIJOIEJOIJE DOIESJOIJCS	$0.0	90468 s	Place Bid
	OITRESITOTIOU dECIOSCIJOJT	$0.0	90447 s	Place Bid
	JIOFDSJF DISJEFFJSOIDFJCIOCJ	$0.0	423 s	Place Bid



Bid Limit:

Active Strategy: No Strategy Selected

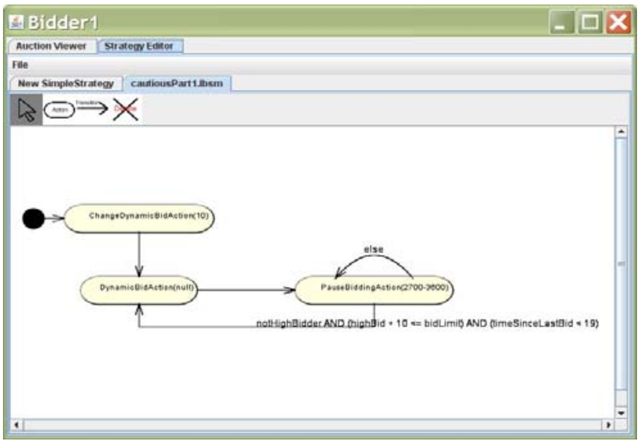
Current High Bidder: SharpSerpent Current High Bid: 12.0

Time Remaining (In Seconds): 89200

Username	Bid Amount	Time of Bid
SharpSerpent	12.0	Apr-13-09 22:13:46 EDT
SharpSerpent	11.0	Apr-13-09 22:13:43 EDT
SharpSerpent	10.0	Apr-13-09 22:13:41 EDT
SharpSerpent	9.0	Apr-13-09 22:13:37 EDT
SharpSerpent	8.0	Apr-13-09 22:13:34 EDT
SharpSerpent	7.0	Apr-13-09 22:13:30 EDT

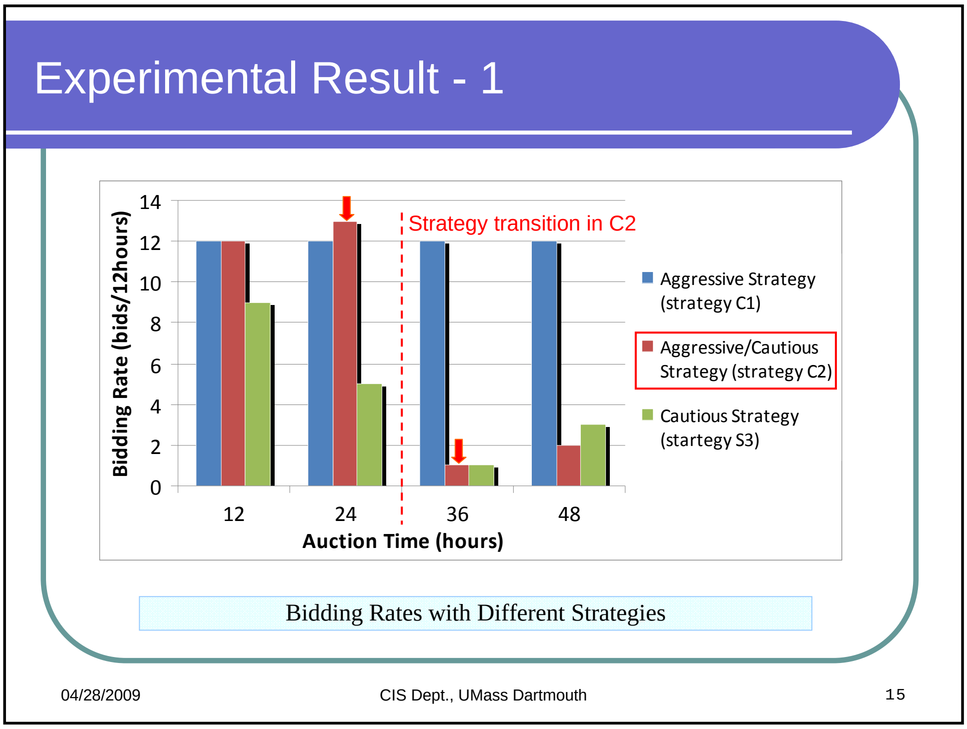
Bid Amount:

Designing Bidding Strategies


Bidder1
Auction Viewer
Strategy Editor
File
New SimpleStrategy
cautiousPart1.lbsm
ChangeDynamicBidAction(10)
DynamicBidAction(null)
PauseBiddingAction(2700-3600)
else
notHighBidder AND (highBid + 10 <= bidLimit) AND (timeSinceLastBid < 19)

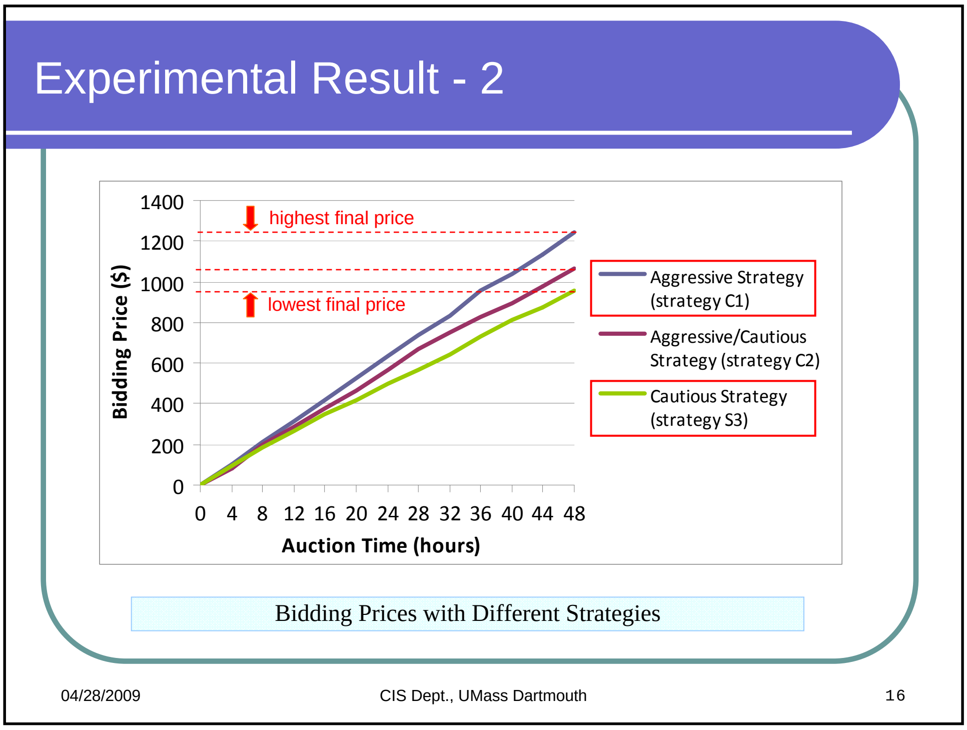
Case Study

- A fictitious auction: an item with an estimated auction price of $1000.
- Six bidding agents: Bidder 1 to Bidder 6
  - Bidder 1-5 are active through the whole auction
  - Bidder 6 joins at the middle of the auction
- Run the auction three time with Bidder 2-6 using a *normal* strategy, but Bidder 1 using one of the three different bidding strategies:
  - Aggressive strategy *C*1 – composed of simple strategy *S*1 and *S*2.
  - Aggressive/Cautious strategy *C*2 – composed of simple strategy *S*1 and *S*3.
  - Cautious strategy *S*3 – simple strategy.



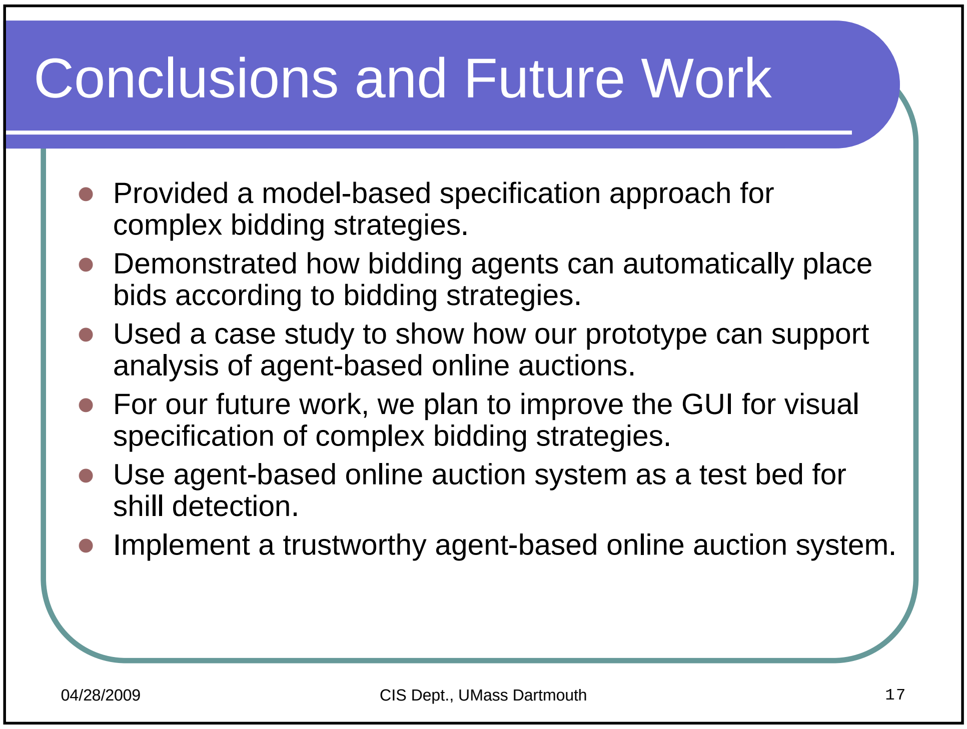
Experimental Result - 1

Bidding Rates with Different Strategies



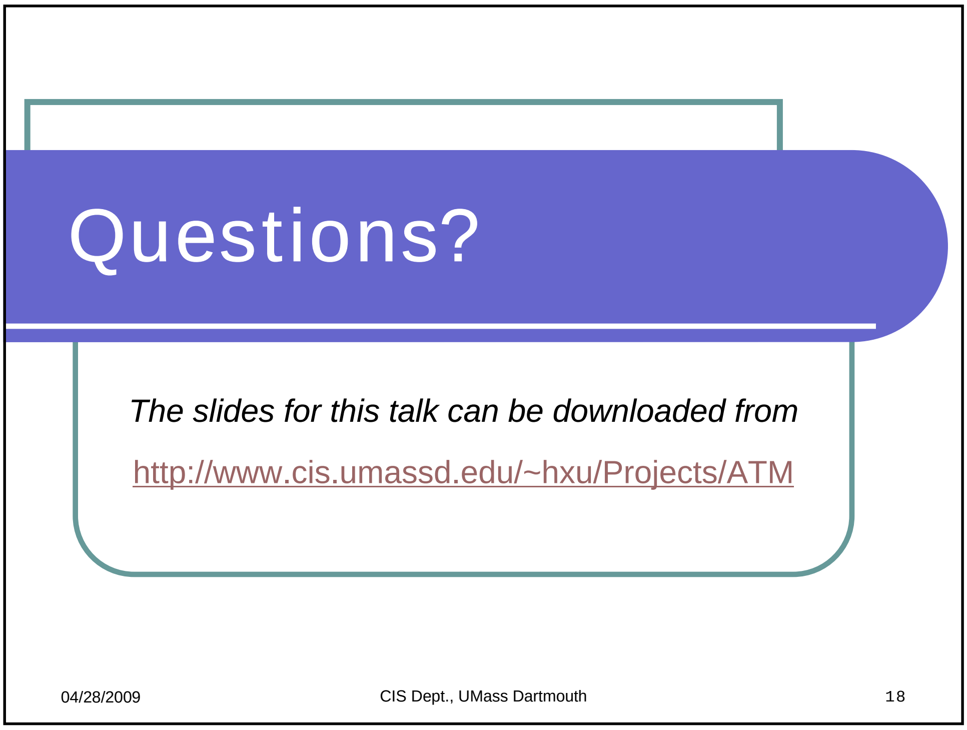
Experimental Result - 2

Bidding Prices with Different Strategies



Conclusions and Future Work

- Provided a model-based specification approach for complex bidding strategies.
- Demonstrated how bidding agents can automatically place bids according to bidding strategies.
- Used a case study to show how our prototype can support analysis of agent-based online auctions.
- For our future work, we plan to improve the GUI for visual specification of complex bidding strategies.
- Use agent-based online auction system as a test bed for shill detection.
- Implement a trustworthy agent-based online auction system.



Questions?

The slides for this talk can be downloaded from

http://www.cis.umassd.edu/~hxu/Projects/ATM