# A Framework for Agent-Based Trust Management in Online Auctions

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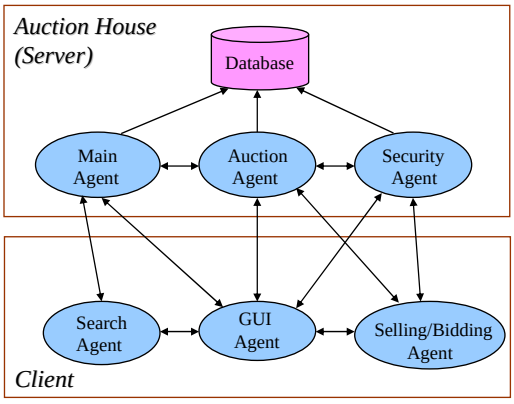
# Online Auctions

- 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




- 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.

*Security agent monitors online auction transactions for any undesired bidding activities, e.g., shilling behaviors.*

# Shilling Behaviors

- A shill bidding is a deliberate activity of placing bids in order to artificially raise the price of an auctioned item.
- Although most of the online auction houses prohibit shilling behaviors, it is easy for malicious users to disguise themselves and put in shill bids in online auctions.
- In a recent research study at Carnegie Mellon University, dozens of probable fraudsters were detected at eBay using data mining techniques.
- It is vital to introduce a feasible trust management mechanism to prevent, detect and avoid trading frauds, such as shilling behaviors.

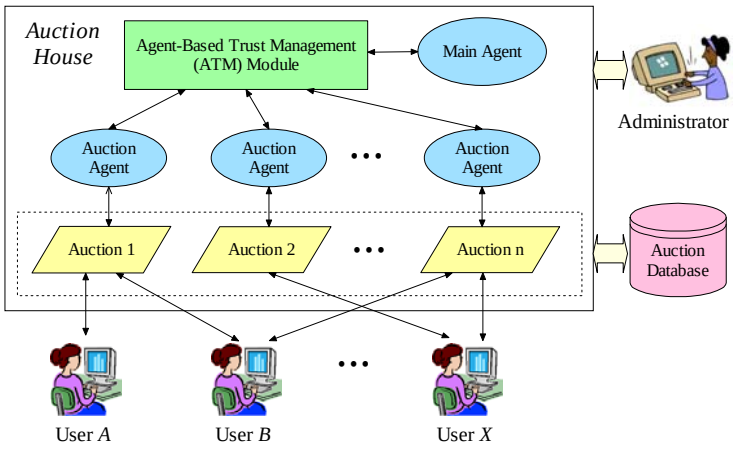


# An Example

While two auctions with the same type of auctioned items are running concurrently, a shill bidder might put bids in the auction with higher bidding price rather than the one with lower bidding price in order to drive up the price in one auction.

- We call this type of shilling behavior *concurrent shilling.*
- Other types of shilling behaviors include: reserve price shilling, competitive shilling etc.
- Shilling behaviors become much more severe in an agent-based online auction system because
  - Automatic detection of shill bidders in agent-based online auctions can be much more difficult.
  - Malicious users may set up bidding strategies and automatically initiate shilling activities.

# A Trustworthy Auction House






# Trust Management

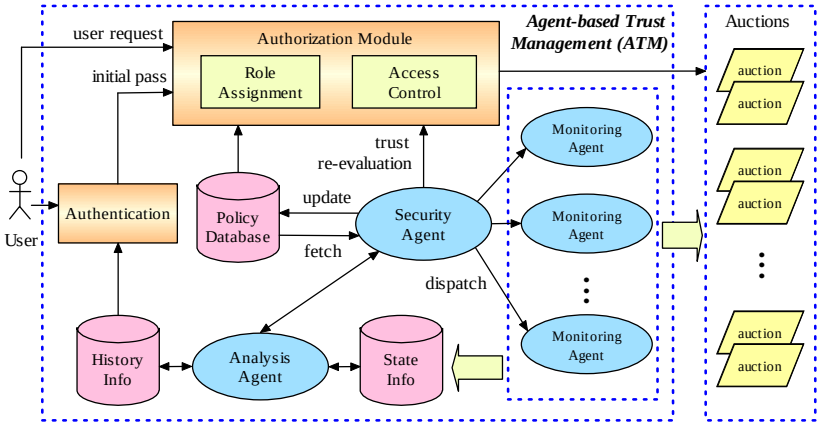
- Trust management has been a promising approach to building trustworthiness in networked systems.
- Two major types of trust management approaches
  - Reputation-based trust management, e.g., in eBay,
    - It uses a very simple reputation based rating scheme for users
    - After each successful transaction, sellers and buyers are invited to rate each other on a 3-point scale, i.e., +1, 0, or -1.
    - The accumulative feedback score of a member represents how other members are satisfied with this member for doing business.
  - Policy-based trust management, e.g., in policyMaker,
    - Credentials and policies are fully programmable
    - Input ($r$, $C$, $P$) → output whether the set $C$ of credentials proves that the request $r$ complies with the local security policy $P$.

# Our Role-Based Approach

- Our approach is a combined approach, which
  - Takes advantages of agent-based technologies.
  - Considers agent reputations stored in a history module.
  - Adopts role-based access control (RBAC) mechanism based on a set of policy rules.
- In an RBAC model, users are assigned roles with permissions
  - Results in reduced administrative costs as compared to associating users directly with permissions.
  - Most of the RBAC models follow the same basic structure of subject, role and privilege.
  - However, in a more sophisticated role-based access control model, access decisions also depend on other factors.
  - We use user's real-time behaviors as factors in our RBAC model. Thus our approach supports dynamic role assignment and access control.



# Agent-Based Trust Management (ATM)



# Examples of Policy Rules

**Table 1. Examples of RA-Policy**

| RA-Policy: A | RA-Policy: B |
|---|---|
| assignRole(Requester, NeutralBidder) ← newUser(Rquester), requestType(Requester, buy). | changeRole(Requester, UnTrustedBidder) ← currentRole(Requester, NeutralBidder), shillingScore(Requester, X, current), X ≥ 0.6, reputationScore(Requester, Y, oneMonth), Y ≤ 0.7. |

**Table 2. Examples of AC-Policy**

| AC-Policy: A | AC-Policy: B |
|---|---|
| allow(Requester, Bid) ← currentRole(Requester, TrustedBidder), shillingScore(Requester, X, current), X ≤ 0.3, reputationScore(Requester, Y, current), Y ≥ 0.6. | disallow(Requester, Bid, oneWeek) ← currentRole(Requester, UnTrustedBidder), shillingScore(Requester, X, current), X ≥ 0.6, reputationScore(Requester, Y, current), Y ≤ 0.7. |



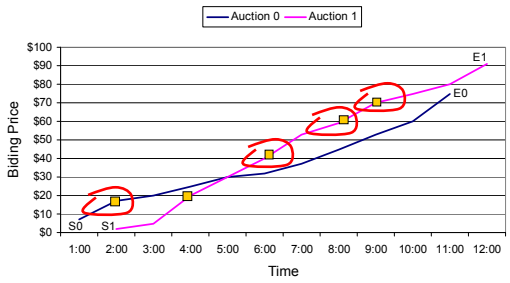
# Auction Data Analysis

- The reputation score is simply an accumulative value of the rating scores from other users
- The shilling score of a user can be calculated using an ***S-Point*** system.

*point(U, 0).*
*point(U, P + 1) :- positive-indication(U, PF), point(U, P).*
*point(U, P - 1) :- negative-indication(U, NF), point(U, P).*

***point(U, P)*** is a predicate that denotes user *U*'s accumulated *S-Points* is *P*.
***positive-indication(U, PF)*** is a predicate that denotes user *U* is a possible shill according to temporal formula *PF*.
***negative-indication(U, NF)*** is a predicate that denotes user *U* is *not* likely a shill according to temporal formula *NF*.

# Model Checking Technology




**S1:** Start of *Auction 1*

**E0:** End of *Auction 0*

**P:** User *A* bids in *Auction 0* && Price is lower in *Auction 1*

**S:** User *A* bids in *Auction 1* && Price is lower in *Auction 0*

**A Predicate for Positive Indication:** after "start of *Auction 1*" until "end of *Auction 0*", does "(User *A* bids in *Auction 0* && Price is lower in *Auction 1*) or (User *A* bids in *Auction 1* && Price is lower in *Auction 0*) become *true*?"

```
([](S1 && !E0 -> (!E0 U(P && !E0)))) || ([](S1 && !E0 ->
(!E0 U(S && !E0))))
```



# Decision Making Process

- The security agent determines whether a shill suspect (detected by a monitoring agent) is an actual shill.
- We propose to use evidence-based theory, e.g., the Dempster-Shafer theory (D-S theory) to support the decision making process.
- Currently, we are working on a Bayesian network with multi-state nodes
  - Calculate the probability of being a shill or a normal user
  - Use additional evidence such as trading history, win-ratio etc.
- Build a feasible intention model for bidding agents to support evaluation of agent behaviors.

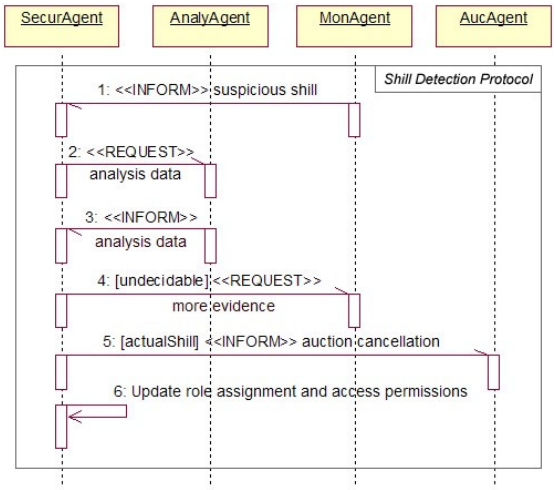
# Agent Communication Language

- Use asynchronous message passing for agent communication.
- FIPA-ACL is an agent communication standard
  - is grounded in speech act theory.
  - defines a set of 22 communicative acts.

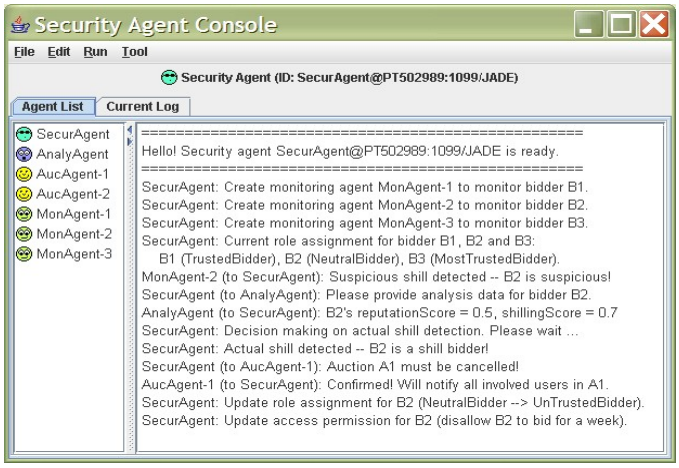
```
(INFORM
 :sender (agent-identifier :name MonAgent-2@PT502989:1099/JADE
     :addresses (sequence http://192.168.1.100:7778/acc))
 :receiver (set (agent-identifier :name SecurAgent@PT502989:1099/JADE
     :addresses (sequence http://192.168.1.100:7778/acc)))
 :content "Suspicious shill B2 detected!"
 :language  "Plain English"
 :ontology  "Online Auctions"
 :protocol  "shill Detection Protocol"
 :conversation-id inform-shill-suspects)
```



# Agent Communication Protocol

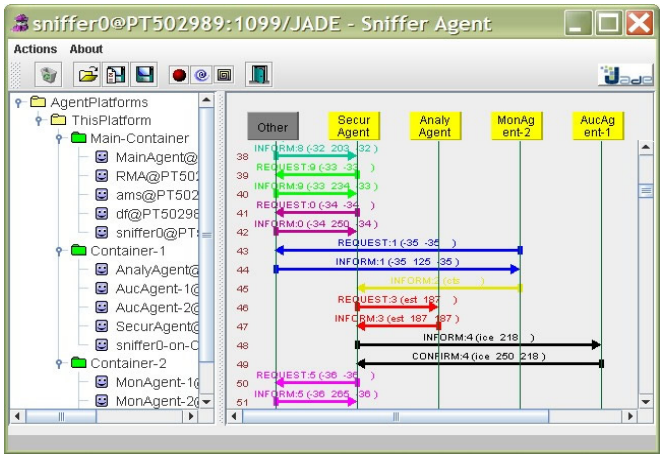


# The Security Agent Interface






# The Sniffer Agent



## Conclusions and Future Work

- We introduced a framework for agent-based trust management for online auctions
- We demonstrated that the agents in the ATM module can effectively communicate with each other
- For our future work, we plan to develop efficient and effective trust management mechanisms
- Formalize shill patterns (and normal bidding patterns), and implement the model checking approach for efficient analysis of auction data
- Develop a prototype trustworthy agent-based online auction systems.



## Questions?

*The slides for this talk can be downloaded from*

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