Engendering Trust in Buying and Selling Agents by Discouraging the Reporting of Unfair Ratings

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Outline

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2. Our Incentive Mechanism
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5. Discussion and Related Work
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Motivations for Our Work

- Electronic marketplace
  - Software agents act on behalf of human users
  - Offloading processing required by people

- Challenge
  - Uncertain and dynamic environment
  - Self-interested agents may engage in deception
    - Selling agents may not deliver promises (untrustworthy)
    - Buying agents may provide unfair reporting of seller reputation

- Intelligent agents
  - Learning behavior of other agents
  - Making effective decisions for human users
  - Engendering trust from users
Motivations for Our Work

Our insight

▶ To allow information sharing within marketplace
   ★ Buyers make decisions with more precise knowledge of sellers
   ★ A personalized approach for buyers to model sellers
   ★ Flexibility to adapt preferences of human users

▶ Honesty is promoted amongst buying agents
   ★ Sharing fair information about sellers allows for successful purchases
   ★ Trustworthy sellers will be reported truthfully and gain sales

An incentive mechanism

▶ Buyers choose neighbors to form social network
▶ Sellers model buyers based on social network
▶ Sellers decrease/increase prices/quality for reputable buyers
▶ Creates incentives for buyers to provide fair ratings
Our Incentive Mechanism

- E-marketplace setting
  - Self-interested buying and selling agents
  - A central server collects and maintains information of agents
  - Buying and selling process is operated as a procurement auction
    - Buyer sends a request to the central server
    - The central server forwards the request to sellers
    - Sellers bid for selling product to the buyer
    - Buyer chooses a winner of auction
    - Buyer submits a rating (binary)

- Buyer’s request

\[
V(p) = \sum_{i=1}^{m} w_i D(f_i) - P(p)
\]
Our Incentive Mechanism

- Seller bidding for buyer’s request
  - Seller’s equilibrium bidding function (Shachat & Swarthout)
    \[ P^*(p) = C(p) + \int_{V'-C_H}^{V'(p)} \frac{F(x)dx}{F(V')} \]
  - The best potential gain for buyer:
    \[ V'(p) = \sum_{i=1}^{m} w_i D(f_i) - C(p) \]
  - Modified equilibrium bidding function
    \[ P^*(p) = C(p) + \int_{V'-C_H}^{V'(p)} \frac{F(x)dx}{F(V')} - V_D(R) \]
Our Incentive Mechanism

- Seller modeling buyer reputation
  - Social network of buyers
    ★ Each buyer has a limited number of neighbors
    ★ Neighbors are the most trustworthy buyers to this buyer
    ★ Modeling trustworthiness of buyers using a personalized approach (Zhang & Cohen 2006)
  - Reputation of buyer
    ★ The number of buyers consider one buyer as their neighbors
      \[
      R(B) = \begin{cases} 
      \frac{N_B}{\theta} & \text{if } N_B < \theta; \\
      1 & \text{otherwise}. 
      \end{cases}
      \]
    ★ The buyer will be considered reputable if \( R(B) \geq \delta' \)
    ★ The buyer will be considered disreputable if \( R(B) \leq \gamma' \)
Our Incentive Mechanism

- Buyer choosing winning seller
  - Winner is the seller whose bid includes the highest valuation
  - Only among trustworthy sellers
  - A personalized approach

  ★ Private reputation: \( R_{pri}(S) = \frac{\sum_{i=1}^{n} N_{pos,i}^B \lambda_i^{i-1} + 1}{\sum_{i=1}^{n} (N_{pos,i}^B + N_{neg,i}^B) \lambda_i^{i-1} + 2} \)

  ★ Public reputation: \( R_{pub}(S) = \frac{\left[ \sum_{j=1}^{k} \sum_{i=1}^{n} N_{pos,i}^A \lambda_i^{i-1} Tr(A_j) \right] + 1}{\left[ \sum_{j=1}^{k} \sum_{i=1}^{n} (N_{pos,i}^A + N_{neg,i}^A) \lambda_i^{i-1} Tr(A_j) \right] + 2} \)
Our Incentive Mechanism

- Buyer choosing winning seller
  - A personalized approach (Cont.)
    - Trustworthiness
      \[ Tr(S) = wR_{pri}(S) + (1 - w)R_{pub}(S) \]
    - Minimum number of own ratings
      \[ N_{min} = \frac{1}{2\varepsilon^2} \ln \frac{1 - \zeta}{2} \]
    - Reliability of private reputation
      \[ w = \begin{cases} \frac{N_{B}^{all}}{N_{min}} & \text{if } N_{B}^{all} < N_{min}; \\ 1 & \text{otherwise.} \end{cases} \]
  - S will be considered trustworthy if \( Tr(S) \geq \delta \)
  - S will be considered untrustworthy if \( Tr(S) \leq \gamma \)
Examples: Buyer $B$ Choosing Winning Seller

- Buyer $B$ wants to buy a product $p$
- Four sellers submitted bids: $S_1, S_2, S_3, S_4$
- $B$ modeling trustworthiness of sellers
  - No personal experience:

  \[
  R_{pri}(S_1|S_2|S_3|S_4) = \frac{0 + 1}{(0 + 0) + 2} = 0.5
  \]

  - Asking advice from its neighbor $A$

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<th>$T_1$</th>
<th>$T_2$</th>
<th>$T_3$</th>
<th>$T_4$</th>
<th>$T_5$</th>
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<td>1</td>
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<tr>
<td>$S_3$</td>
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<td>1</td>
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<td>1</td>
<td>1</td>
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<tr>
<td>$S_4$</td>
<td>1</td>
<td>1</td>
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<td>1</td>
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</tbody>
</table>
Examples: Buyer $B$ Choosing Winning Seller

- $B$ modeling trustworthiness of sellers (Cont.)
  - Public reputation of sellers ($\lambda = 0.9$, $Tr(A) = 0.9$)
    
    $$R_{pub}(S_1) = \frac{\sum_{i=4}^{5} 1 \times 0.9^{i-1} \times 0.9 + 1}{\sum_{i=1}^{5} 1 \times 0.9^{i-1} \times 0.9 + 2} = 0.39$$
    
    $$R_{pub}(S_2) = 0.5, \quad R_{pub}(S_3) = 0.83, \quad R_{pub}(S_4) = 0.72$$
  
  - Trustworthiness of sellers
    
    $$Tr(S_1) = 0 \times 0.5 + (1 - 0) \times 0.39 = 0.39$$
    
    $$Tr(S_2) = 0.5, \quad Tr(S_3) = 0.83, \quad Tr(S_4) = 0.72$$
  
  - Threshold $\delta = 0.7$: only $S_3$ and $S_4$ are trustworthy
Examples: Buyer $B$ Choosing Winning Seller

- $B$ choosing business partner
  - $B$’s evaluation criteria for $p$
    - Features
      - Delivery Time (day) | Warranty (year)
        - Weights | 0.4 | 0.6
        - Descriptive | 7 3 1 | 1 2 3
        - Numerical | 3 5 10 | 3 5 10
    - Values of their products
      - $S_3$ promises to deliver $p$ with 3 year warranty in 3 days:
        $$V(p, S_3) = 0.4 \times 5 + 0.6 \times 10 - 4 = 4$$
      - $S_4$ promises to deliver $p$ with 2 year warranty in 3 days: $V(p, S_4) = 1$
    - $S_3$ is the winner
    - $S_3$ keeps its promise, $B$ submits "1" to the central server
Examples: Seller Bidding for Buyers’ Requests

- **Seller** $S_5$ modeling reputation of buyers
  - The number of neighborhoods for each buyer
    $$N_{B_1} = 0, \quad N_{B_2} = 1, \quad N_{B_3} = 3, \quad N_{B_4} = 4, \quad N_{B_5} = 5, \quad N_{B_6} = 5$$
  - Reputation of each buyer ($\theta = 6$)
    $$R(B_1) = 0, \quad R(B_2) = 0.17, \quad R(B_3) = 0.5$$
    $$R(B_4) = 0.67, \quad R(B_5) = 0.83, \quad R(B_6) = 0.83$$
  - $B_5, B_6$ are reputable; $B_1, B_2$ are disreputable ($\delta' = 0.8, \gamma' = 0.3$)

- **Seller’s bid for each buyer**

<table>
<thead>
<tr>
<th>Buyers</th>
<th>Features of Product</th>
<th>Profit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Warranty</td>
<td>Delivery Time</td>
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<tr>
<td>$B_1, B_2$</td>
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<td>1 week</td>
</tr>
<tr>
<td>$B_3, B_4$</td>
<td>2 years</td>
<td>3 days</td>
</tr>
<tr>
<td>$B_5, B_6$</td>
<td>3 years</td>
<td>1 day</td>
</tr>
</tbody>
</table>
Experiment Setting

- A marketplace operating in 20 days

- 100 buyers
  - Each 10 buyers has different numbers (2-20) of requests
  - Maximum of one request each day
  - One product in each request
  - Products have same non-price features
  - 50 of them provide unfair ratings (from 10% to 50%)
  - 5 neighbors

- 10 sellers
  - Each 2 acts dishonestly in different percentages (0% - 100%)
  - One half of them model reputation of buyers
  - Another half offer the same price
  - Have the same cost for producing products
Experimental Results

- Buyer providing fewer unfair ratings will have larger reputation value

![Graph showing number of neighborhoods over days for buyers not lying and lying 20% and 40%, with trendlines indicating decreasing values over time.](image-url)
Experimental Results

- Buyer having more requests will have larger reputation value
Experimental Results

- Buyer providing fewer unfair ratings will gain more total profit
Experimental Results

- Seller being honest more often will have larger average trust
- Seller not modeling buyers will have smaller average trust
Experimental Results

- Seller being honest more often will gain more total profit.
Experimental Results

- Seller modeling reputation of buyer will gain more total profit
Discussion and Related Work

- **Others’ incentive mechanisms**
  - **Side payment** (Jurca & Faltings; Miller et al.)
    - Offer payment to buyers providing fair ratings
    - Providing fair ratings is a Nash equilibrium
  - **Credibility** (Papaioannou & Stamoulis; Jurca & Faltings)
    - Measure agents’ credibility
    - Credibility decreases if ratings provided by participants are different

- **Our mechanism**
  - Agents learn about each other, to make effective decisions
    - Selling agents model reputation of buyers
    - Buying agents personalize decision making for their users
  - Honest agents will gain better profit for human users
  - Trust between agents and their users will be fostered
Research Issues for the Future

- How best to capture users’ preference
  - User-specific factors
    - To weight private and public reputation of sellers differently
    - Threshold $\delta$ for sellers to be considered trustworthy
  - Building user modeling values
    - General user models, stereotypes and specific user modeling features (Fleming & Cohen)

- Identity of buyers is shielded
  - To prevent sellers from cheating less reputable buyers

- More comprehensive approach for modeling buyers’ reputation
  - Considering reputation of buyers that include buyer in neighbor list