

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

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Outline

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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)

$$P^*(p) = C(p) + \frac{\int_{V_L - C_H}^{V'(p)} F(x) dx}{F(V')}$$

- ▶ The best potential gain for buyer:

$$V'(p) = \sum_{i=1}^m w_i D(f_i) - C(p)$$

- ▶ Modified equilibrium bidding function

$$P^*(p) = C(p) + \frac{\int_{V_L - C_H}^{V'(p)} F(x) dx}{F(V')} - V_D(R)$$

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

$$\star \text{ Private reputation: } R_{pri}(\mathcal{S}) = \frac{\sum_{i=1}^n N_{pos,i}^B \lambda^{i-1} + 1}{\sum_{i=1}^n (N_{pos,i}^B + N_{neg,i}^B) \lambda^{i-1} + 2}$$

$$\star \text{ Public reputation: } R_{pub}(\mathcal{S}) = \frac{\left[\sum_{j=1}^k \sum_{i=1}^n N_{pos,i}^{A_j} \lambda^{i-1} Tr(A_j) \right] + 1}{\left[\sum_{j=1}^k \sum_{i=1}^n (N_{pos,i}^{A_j} + N_{neg,i}^{A_j}) \lambda^{i-1} Tr(A_j) \right] + 2}$$

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

$$w = \begin{cases} \frac{N_{all}^B}{N_{min}} & \text{if } N_{all}^B < N_{min}; \\ 1 & \text{otherwise.} \end{cases}$$

- ▶ 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

T	T_1	T_2	T_3	T_4	T_5
S_1	0	0	0	1	1
S_2	-	-	-	-	-
S_3	1	1	1	1	1
S_4	1	1	1	1	0

Examples: Buyer B Choosing Winning Seller

- B modeling trustworthiness of sellers (Cont.)

- ▶ Public reputation of sellers ($\lambda = 0.9$, $Tr(A) = 0.9$)

$$R_{pub}(S_1) = \frac{\sum_{i=4}^5 1 * 0.9^{i-1} * 0.9 + 1}{\sum_{i=1}^5 1 * 0.9^{i-1} * 0.9 + 2} = 0.39$$

$$R_{pub}(S_2) = 0.5, \quad R_{pub}(S_3) = 0.83, \quad R_{pub}(S_4) = 0.72$$

- ▶ Trustworthiness of sellers

$$Tr(S_1) = 0 * 0.5 + (1 - 0) * 0.39 = 0.39$$

$$Tr(S_2) = 0.5, \quad Tr(S_3) = 0.83, \quad Tr(S_4) = 0.72$$

- ▶ 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:

$$V(p, S_3) = 0.4 * 5 + 0.6 * 10 - 4 = 4$$

- ★ 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
 $N_{B_1} = 0, N_{B_2} = 1, N_{B_3} = 3, N_{B_4} = 4, N_{B_5} = 5, N_{B_6} = 5$
 - ▶ Reputation of each buyer ($\theta = 6$)
 $R(B_1) = 0, R(B_2) = 0.17, R(B_3) = 0.5$
 $R(B_4) = 0.67, R(B_5) = 0.83, R(B_6) = 0.83$
 - ▶ B_5, B_6 are reputable; B_1, B_2 are disreputable ($\delta' = 0.8, \gamma' = 0.3$)
- Seller's bid for each buyer

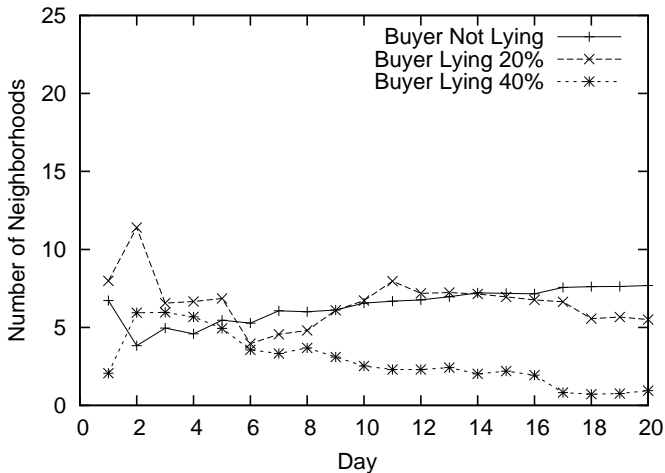
Buyers	Features of Product			Profit
	Warranty	Delivery Time	Price	
B_1, B_2	1 year	1 week	5	-2
B_3, B_4	2 years	3 days	4	1
B_5, B_6	3 years	1 day	3	7

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

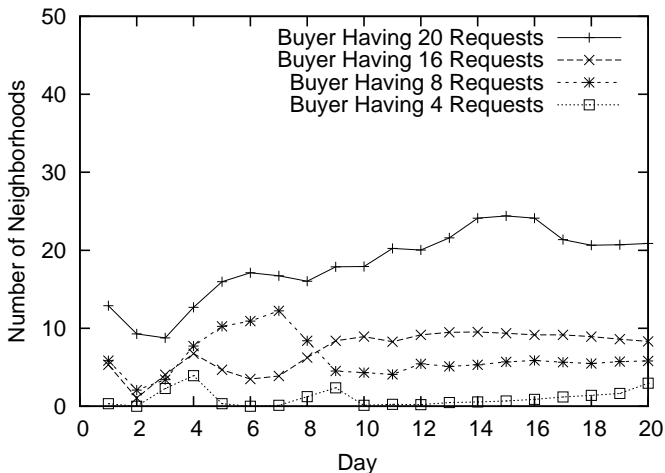
Experimental Results

- Buyer providing fewer unfair ratings will have larger reputation value



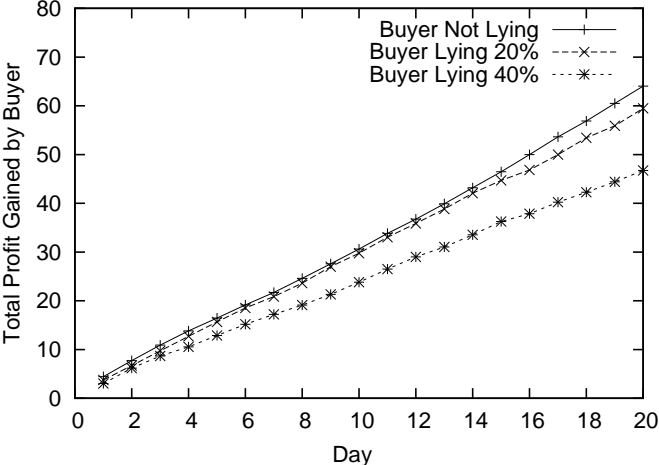
Experimental Results

- Buyer having more requests will have larger reputation value



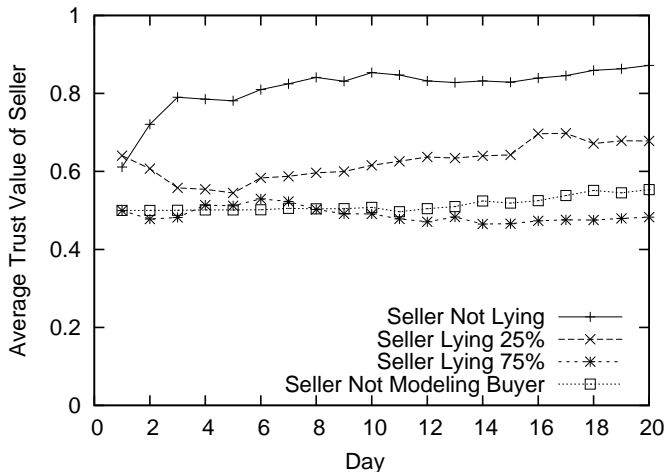
Experimental Results

- Buyer providing fewer unfair ratings will gain more total profit



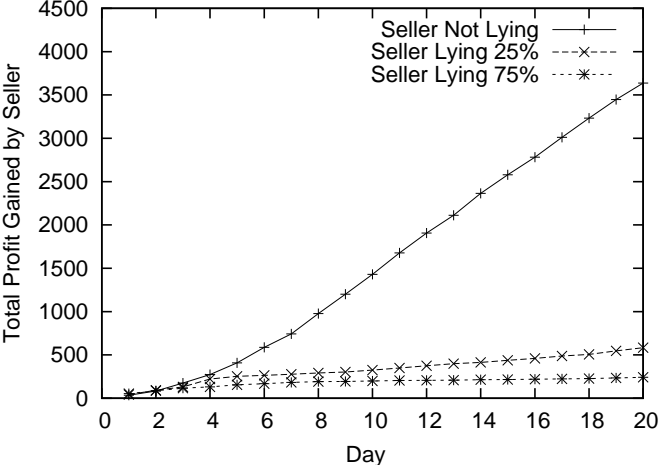
Experimental Results

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



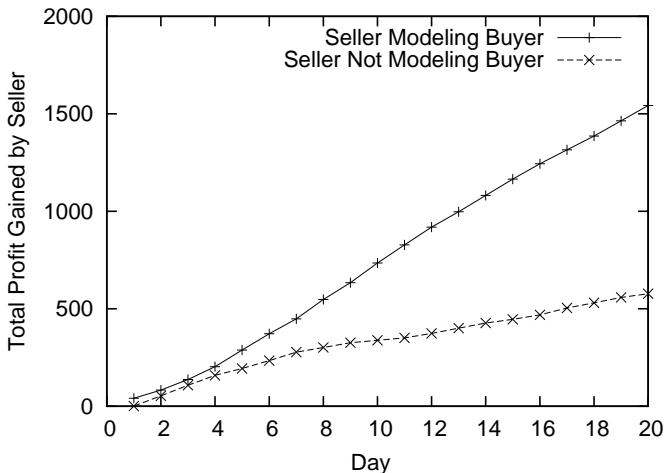
Experimental Results

- 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 δ 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