Agent–Human Negotiations in E–Commerce: Alternate Strategies for a Win–Win Seeking Agent

Dr. Yang Yinping
Scientist & Independent Investigator
Institute of High Performance Computing (IHPC)
Agency for Science, Technology and Research (A*STAR), Singapore

Scientist (2007–Present)


Main experience and accomplishment

- **Industry collaboration** (HP), **field studies** in China (Alibaba and GS trade shows), **cross-disciplinary collaboration** (computer science, psychology and practitioners)

- 2 **best paper awards** (WITS06, HICSS09), 1 **best prototype award** (WITS09), 1 **US patent filed**

- **IHPC Independent Investigator Award** (2011–2014)

To learn more about me, visit my profile at IHPC [http://www.ihpc.a-star.edu.sg/yangyp.php?display=1](http://www.ihpc.a-star.edu.sg/yangyp.php?display=1)
Alternate Strategies for a Win–Win Seeking Agent in Agent–Human Negotiations

Co–authors Sharad Singhal and Yunjie (Calvin) Xu

Initial study presented at ICIS2009; currently under second round review at a top IS journal
Background and practical motivation
Existing e-commerce technologies are limited to meet the need of “mass customization”

Auction-based price discovery

Product configuration (customization)?
Existing e-commerce technologies are limited to meet the need of “mass customization”

Instant computer configuration tool

Multiple sales contract issues (Price, quantity and warranty terms) together?
Existing e-commerce technologies are limited to meet the need of "mass customization"

Instant buy-sell messaging tools that facilitate customization and negotiation

Human operated
The promise of negotiation agent technologies

- Capable of multiple-issue offers evaluation and exchange
- Autonomous
- Rational decision making and more efficient settlement
- Cost – and Revenue +

Ref: Oliver 1997; Rangaswamy and Shell 2000
Overview

- Design challenge and theoretical motivation
- The win-win agent design model and system prototype
- Design evaluation: an experiment
- Discussions and conclusions
Design challenge and theoretical motivation
Key challenge: incomplete information

Heuristics based models
Faratin et al. (1998) – time, resource, and behavior dependent tactics
Matwin et al. (1991), and Goh et al. (2002) – time based concession
Strategies are competitive, win–lose in nature for single–issue negotiation; does not incorporate the opportunity for tradeoffs
Key challenge: incomplete information

Multi-issue negotiation
e.g., a service contract

- Quantity: ___
- Service Level: ___
- Delivery Schedule: ___
- Warranty Terms: ___
- Unit Price: ___

***************
Total payment: ___

Machine learning methods
Faratin et al. (2002) -- “fuzzy similarity” based tradeoff method
Coehoorn and Jennings (2004) -- “kernel density estimation” method
Ros & Sierra (2006) -- “variability” method

Assume the availability of the counterpart’s preferences or the availability of past negotiation history
Our research model
# Our research model

**Existing literature: agent–agent context; pure economic evaluation and assumptions; extensive focus on offer strategy**

<table>
<thead>
<tr>
<th>Components of a Design Theory (Walls et al. 1992)</th>
<th>Components of the Proposed Negotiation Agent Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Kernel Theory</td>
<td>Dual concern model</td>
</tr>
<tr>
<td>2. Meta-Requirements</td>
<td>A win-win seeking negotiating agent (1) to achieve better economic outcomes for itself, and (2) to achieve better socio-economic outcomes for its human counterpart, (3) within a reasonable number of rounds. Evaluation metrics that incorporate a socio-economic perspective of negotiation outcomes: counterpart agreement ratio, individual outcome, dyadic outcome, counterpart’s perception of the outcome, and counterpart’s perception of the agent.</td>
</tr>
<tr>
<td>3. Meta-Design</td>
<td>Two major design features, i.e., an offer strategy and an acceptance strategy, to comprise a complete negotiation strategy</td>
</tr>
<tr>
<td>4. Testable Design Product and Hypotheses</td>
<td>An agent artifact that embodies two new strategies, i.e., the simultaneous-equivalent offers and delayed acceptance strategies, are more likely to produce better socio-economic outcomes in comparison to sequential-single offer and immediate acceptance strategies</td>
</tr>
</tbody>
</table>

1. **Agent–human context**
2. **Socio–economic evaluation and relaxed assumption**
3. **Complete strategy design**
Problem scope

- Information privacy with regard to others
  - Preferences: multi-attribute utility (MAU) function
  - Reservation condition: best alternative to a negotiated agreement (BATNA)

- Protocol/rules compliance
  - bilateral alternate offer protocol, plus
  - final offer rule

- Multiple negotiation issues
The focal offer strategy and acceptance strategy design
Design analysis

100         Buyer’s Utility Value

Seller’s Utility Value

100

Seller’s Reservation Utility (BATNA)

Seller’s Starting Offer

Seller’s Target Utility

100

Buyer’s Reservation Utility (BATNA)

0

Bargaining Zone

Nash Equilibrium

Pareto Efficient Frontier

How can a seller make offers?

How can a seller decide to accept the buyer’s offer?
Offer strategy (SEO vs. SIM)

- **sequential–single offer (SEQ) strategy**: start with an offer of high self-utility and conceding in certain patterns

- **simultaneous–equivalent offers (SIM)**: employ an “offer selection method” to send the counterpart multiple offers in each round
  - H1: higher counterpart acceptance ratio
  - H2: higher individual outcome
  - H3: higher joint outcome
  - H4: counterpart’s greater satisfaction with the outcome
  - H5: counterpart's greater perceived cooperativeness with the agent
Acceptance strategy (IMM vs. DLY)

- **Immediate acceptance (IMM) strategy**: accepts a counteroffer when it exceeds a single decision threshold.

- **Delayed acceptance (DLY) strategy**: employ a parameter of “aspiration region” to respond to a counteroffer that meets its reservation utility.
  - H6: higher individual outcome
  - H7: higher joint outcome
  - H8: counterpart’s greater satisfaction with the outcome
System architecture and strategy implementation

Negotiation client URL (front end):
http://202.83.249.16/LaptopOnDemand

Negotiation service URL (backend):
http://202.83.249.16/negotiation
Design evaluation
1. 2x2 factorial (n=110), random assignment
2. 110 working professionals and executives recruited in December 2008
3. Tired incentives: S$20 participation, S$50, S$30, S$20 bonus for top 30%, top performer smart phone (S$750)
Negotiation task

Four issues – price, quantity, delivery, service of laptop computers (adapted from Jones 1988)

- buyer–seller has different issue weightings over issues, so

- none-zero-sum game to allow for integrative outcome (784 alternatives)

- equal BATNA (= 44) to control bargaining power
Appendix A. Negotiation Task for Buyer

The Brokens Electronics Inc. is one of the top suppliers of IT products and services in the Asia Pacific region. During the first three quarters of 2008, sales revenues increased slightly. However, as a portion of market share, sales do not look good. The Brokens' market share remained constant during the first two quarters and has dropped slightly during the third quarter. As sales efforts to reverse this trend, the marketing research department has proposed launching a new laptop computer model in January 2009, which would sell at a lower price than its chief competitor.

The Brokens do business regularly with three major suppliers. All offer quality laptop computers and good services and the Brokens is confident that it can expect the same good performance in the future from these companies.

You are representing the purchasing manager of The Brokens to purchase a number of branded laptop computers. In this task, you will be negotiating with the vendor manager from LaptopOnDemand, one of the three suppliers, through its portal website. The following specifies your company's negotiation guidelines in negotiating the purchase agreement.

Negotiation Issues and Utility Table

The two critical issues for your company are unit price and technical support. Your company is reviewing an offer of a new laptop computer to reverse the trend of declining market share. The two main ways for this laptop computer to penetrate the market are through competitive pricing and an innovative service plan. Thus, the price must be kept low and the technical support level must be high.

Your company also considers the delivery time of the first shipment. In order to capitalize on sales, your company desires an early shipment date, the earlier the better. Observe purchase quantity is also important to you. The quantity of purchases should be at least 150 units and no larger than 200 units (because of physical limitations on inventory storage space). With this limit, your company prefers a low unit price, the lower the better. These two issues are important but are not ranked as unit price and technical support.

The following utility table summarizes your negotiation task in quantified terms. Utility points are assigned, in relative terms, low, favorable, or satisfying a value is an issue's negotiation weight for your company. The higher the utility points, the more favorable to the corresponding issue in your company. For example, $2,250/unit is compared with higher utility than $2,300/unit.

<table>
<thead>
<tr>
<th>Unit Price</th>
<th>$2,000</th>
<th>$2,100</th>
<th>$2,150</th>
<th>$2,200</th>
<th>$2,250</th>
<th>$2,300</th>
<th>$2,350</th>
</tr>
</thead>
<tbody>
<tr>
<td>Utility</td>
<td>39</td>
<td>33</td>
<td>27</td>
<td>20</td>
<td>13</td>
<td>7</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Quantity</th>
<th>100 units</th>
<th>120 units</th>
<th>140 units</th>
<th>160 units</th>
<th>180 units</th>
<th>200 units</th>
<th>220 units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Utility</td>
<td>15</td>
<td>13</td>
<td>11</td>
<td>8</td>
<td>5</td>
<td>3</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Support</th>
<th>Platinum</th>
<th>Gold</th>
<th>Silver</th>
<th>Classic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Utility</td>
<td>29</td>
<td>19</td>
<td>10</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Delivery</th>
<th>1 week</th>
<th>2 weeks</th>
<th>3 weeks</th>
<th>4 weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Utility</td>
<td>17</td>
<td>10</td>
<td>5</td>
<td>0</td>
</tr>
</tbody>
</table>

The Bottom Line

As an experienced purchasing manager you have explored possible agreements with the other two major suppliers. One supplier could not make delivery before the deadline, so you ruled that company out. The other has made the following final offer:

<table>
<thead>
<tr>
<th>Price</th>
<th>$2,250/unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantity</td>
<td>140 units</td>
</tr>
<tr>
<td>Support</td>
<td>Silver</td>
</tr>
<tr>
<td>Delivery</td>
<td>2 weeks</td>
</tr>
</tbody>
</table>

So you know that there is no point in reaching an agreement with LaptopOnDemand if it is not at least as good as this offer. By referring to the utility table, you can see that you are already guaranteed a utility score at 44 (13+11+10+10=44). So, you should try to strike an agreement that is better than this offer – in a sense, this is your bottom line of this negotiation.
<AgentConfiguration name="Irene" debug="false" SIM="true" DLY="true">

<Issue name="price" units="S$/unit" min="2050" max="2350" delta="50" weight="0.15">
</Issue>

<Issue name="quantity" units="units" min="100" max="220" delta="20" weight="0.37">
</Issue>

<Issue name="support" weight="0.20">
    <Labels>Platinum, Gold, Silver, Classic</Labels>
    <UtilityFunction type="table"> 0.,0.,1.,7.,2.,13.,3.,20. </UtilityFunction>
</Issue>

<Issue name="delivery" units="week(s)" min="1" max="4" delta="1" weight="0.28">
    <UtilityFunction type="table"> 1.,0.,2.,9.,3.,19.,4.,28. </UtilityFunction>
</Issue>

BATNA: price, 2250, quantity, 140, support, Silver, delivery, 2
MaxUtility value="100"/>

U_initial value="80"/>
U_target value="60"/>
U_reservation value="44"/>
R_max value="9"/>
ConcessionPattern> 8.0, 7.0, 6.0, 5.0, 4.0, 3.0, 2.0, 1.0 </ConcessionPattern>
Messages> a set of messages that indicate different stages of the offer exchanges </Messages>
</AgentConfiguration>
Experiment procedure

Pre-negotiation
1. Read about the negotiation task (role = buyer) & bonus scheme
2. A quiz to ensure they understand the task
3. Negotiation rules (bilateral alternate offers; final offer)
4. Training on using the system

Negotiation
No time limit from the experimenter

Post-negotiation
1. Post-negotiation questionnaire
2. Debriefing
### Dependent measures

- **Counterpart’s agreement ratio**
- Individual outcomes for buyer a and seller b \((U_{xa} + U_{ya} + U_{za})\) and \((U_{xb} + U_{yb} + U_{zb})\).
- **Pareto efficiency is calculated as distance to the Pareto-efficient frontier as**
  \[
  \min_{i=1}^{n} \sqrt{(U_a - U_{ai})^2 + (U_b - U_{bi})^2}
  \]
- **Satisfaction with the Outcome, Perceived Cooperativeness**

<table>
<thead>
<tr>
<th>Constructs</th>
<th>(Code) Items</th>
<th>Scale</th>
<th>Source(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Satisfaction with the Outcome</td>
<td>(SA.1) How satisfied are you with the utility score you earned?</td>
<td>1-Extremely dissatisfied, 4-Indifferent, 7-Extremely satisfied</td>
<td>Carman et al. [8]; Foroughi et al. [15]; Ranganathan and Shi [42]; Oliver et al. [55]</td>
</tr>
<tr>
<td></td>
<td>(SA.2) How satisfied are you with the values of the agreement?</td>
<td>1-Extremely dissatisfied, 4-Indifferent, 7-Extremely satisfied</td>
<td></td>
</tr>
<tr>
<td>Perceived Cooperativeness</td>
<td>(PC.1) Do you think the seller was considerate about your interests and concerns?</td>
<td>1-Extremely inconsiderate, 4-Moderately, 7-Extremely considerate</td>
<td>Carman et al. [8]; Foroughi et al. [15]</td>
</tr>
<tr>
<td></td>
<td>(PC.2) Do you think the seller was flexible in making offers to you?</td>
<td>1-Extremely rigid, 4-Moderately, 7-Extremely flexible</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(PC.3) Do you think the seller was friendly?</td>
<td>1-Extremely unfriendly, 4-Moderately friendly</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(PC.4) Do you think the seller was flexible in making flexible</td>
<td>1-Extremely rigid, 4-Moderately flexible</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(PC.5) What kind of “overall” impression did the seller make on you?</td>
<td>1-Extremely negative, 4-Neither negative nor positive, 7-Extremely positive</td>
<td></td>
</tr>
</tbody>
</table>
Data analysis
Construct Validity, Reliability Tests and Control Check

- **Construct validity** of the subjective dependent variables: confirmed with satisfable Cronbach’s alpha (>0.7) convergent (>0.5) and discriminant validity (<0.4)

- **Control check**: confirmed the controlled variables (subjects age, gender, experience, pre-negotiation expectation etc.) do not vary significantly across the treatment conditions (p<0.05)

- **Manipulation checks** over the system logs: ensured the implementation of the strategies were in accordance with the conceptual level design
Results
Greater counterpart agreement ratio in SIM condition

Counterpart acceptance ratio

Reference: overall agreement ratio (accepted by both sellers and buyers) 80.0%

SEQ (baseline) SIM (treatment)

B=1.105, p=0.007**

38.2% 41.8%

SEQ (baseline) SIM (treatment)

B=0.270, p=0.505
**Better economic and social-psychological outcomes**

<table>
<thead>
<tr>
<th>Dependent Measures</th>
<th>Mean (Std. Deviation)</th>
<th>$\eta^2_p$</th>
<th>Power</th>
<th>F</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SEQ</td>
<td>SIM</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Buyer Utility</td>
<td>59.95 (11.48)</td>
<td>66.11 (13.48)</td>
<td>.061</td>
<td>.736</td>
<td>6.834</td>
</tr>
<tr>
<td>Seller Utility</td>
<td>48.89 (5.96)</td>
<td>48.87 (7.28)</td>
<td>.000</td>
<td>.052</td>
<td>0.015</td>
</tr>
<tr>
<td>Joint Utility</td>
<td>108.84 (14.05)</td>
<td>114.98 (14.95)</td>
<td>.043</td>
<td>.585</td>
<td>4.817</td>
</tr>
<tr>
<td>Dis. to Pareto Frontier</td>
<td>14.62 (10.32)</td>
<td>10.34 (10.82)</td>
<td>.040</td>
<td>.551</td>
<td>4.436</td>
</tr>
<tr>
<td>Dis. to Nash Solution</td>
<td>20.50 (8.35)</td>
<td>20.87 (7.73)</td>
<td>.001</td>
<td>.060</td>
<td>0.086</td>
</tr>
<tr>
<td>Satisfaction with Outcome</td>
<td>3.61 (1.60)</td>
<td>4.38 (1.60)</td>
<td>.056</td>
<td>.700</td>
<td>6.290</td>
</tr>
<tr>
<td>Perceived Cooperativeness</td>
<td>3.56 (0.96)</td>
<td>4.16 (1.04)</td>
<td>.085</td>
<td>.873</td>
<td>9.784</td>
</tr>
<tr>
<td></td>
<td>IMM</td>
<td>DLY</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Buyer Utility</td>
<td>63.87 (12.95)</td>
<td>62.21 (12.79)</td>
<td>.006</td>
<td>.122</td>
<td>0.618</td>
</tr>
<tr>
<td>Seller Utility</td>
<td>47.07 (5.27)</td>
<td>50.63 (7.34)</td>
<td>.073</td>
<td>.815</td>
<td>8.303</td>
</tr>
<tr>
<td>Joint Utility</td>
<td>110.94 (14.14)</td>
<td>112.84 (15.42)</td>
<td>.003</td>
<td>.091</td>
<td>0.360</td>
</tr>
<tr>
<td>Dis. to Pareto Frontier</td>
<td>12.99 (10.36)</td>
<td>11.99 (11.18)</td>
<td>.002</td>
<td>.069</td>
<td>0.169</td>
</tr>
<tr>
<td>Dis. to Nash Solution</td>
<td>21.99 (6.90)</td>
<td>19.42 (8.84)</td>
<td>.026</td>
<td>.389</td>
<td>2.867</td>
</tr>
<tr>
<td>Satisfaction with Outcome</td>
<td>3.98 (1.72)</td>
<td>4.01 (1.58)</td>
<td>.000</td>
<td>.050</td>
<td>0.000</td>
</tr>
<tr>
<td>Perceived Cooperativeness</td>
<td>3.87 (1.05)</td>
<td>3.85 (1.05)</td>
<td>.001</td>
<td>.057</td>
<td>0.064</td>
</tr>
</tbody>
</table>
**Hypotheses testing summary**

**Simultaneous-equivalent offers (SIM) strategy** enables a negotiation agent to send the counterpart multiple offers in each round:
- H1: higher counterpart acceptance ratio
- H2: higher individual outcome
- H3: higher joint outcome
- H4: counterpart’s greater satisfaction with the outcome
- H5: counterpart's greater perceived cooperativeness with the agent

![Agreement ratio](checkmark)
- Economic outcomes
- Social-psychological outcomes

**Delayed acceptance (DLY) strategy**: explore better deals by employing a parameter of “aspiration region” to respond to a counteroffer that meets its reservation utility:
- H6: higher individual outcome
- H7: higher joint outcome
- H8: counterpart’s greater satisfaction with the outcome

![Economic outcomes](checkmark)
- Social-psychological outcomes

Possible explanations for H8: the counterfactual thinking that negotiators tend to feel “settled too early” (Galinsky et al. 2002) was not triggered due to high incentive

Post–hoc analysis
- Positive perception under SIM extended to non-agreement cases
- Subjects’ satisfaction with the outcome ($p=0.001$) and perceived cooperativeness of the agent ($p=0.000$) positively linked to subjects’ desire for future negotiation with the agent
Recap

- Design challenge and theoretical motivation
- The win–win agent design model
- Design evaluation: an experiment
- Discussions and conclusions
Conclusion

- The proposed offer and acceptance strategies can lead to better negotiation outcome from a social-economic perspective, compared to conventional strategies.

- A complete design science approach in accordance to Walls et al. (1992)

- Innovative e-commerce technologies and implications to e-commerce and online intermediaries.
Future research directions

- Design improvements on the SIM strategy
  - Simultaneous *un-equivalent* offers
  - Learning embedded

- Complex preferences functions
  - additive vs. non-additive utility functions

- Cloud computing market as an application domain
Thank you.

More about my research program at IHPC, A*STAR:
http://www.ihpc.a-star.edu.sg/i3.php

Contact me:
yangyp@ihpc.a-star.edu.sg