Agent-Based e-Marketplaces - an Overview

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Outline

E-MARKETPLACE

E-MARKETPLACE

Is an online, parallel to physical marketplace. It can exists in different forms including:

- auctions
- product exchanges
- online shopping markets
- e-catalogs

Comparison of e-marketplace to traditional marketplace

- potential buyers and sellers exchange information about goods or services, reaching agreement through information alone
- buyer may search the best from the huge number of products available on the e-marketplace
- merchants can promptly react on the situation on the e-marketplace to satisfy potential customers in a more effective manner

Automated Negotiations

What for?

- buyers need to be provided with the mechanisms that help them to specify their preferences and search for the best choices based on preferences
- preferences both on the selling and buying sides are vague

Solution to new challenge

Software agents' paradigm

Practical Implementations - CBB Model

Consumer Buying Behaviour

The CBB model augments traditional marketing models with concepts from Software Agents research to accomodate electronic markets.

Six stages guiding consumer buying behaviour

1. **Need Indentification** - consumer becomes aware of some unmet need and is stimulated through product information
2. **Product Brokering** - the retrieval of information to help determine *what* to buy; this encompasses the evaluation of product alternatives based on consumer-provided criteria; result of this stage is 'consideration set' of products.

CBB Model cont.

Six stages guiding consumer buying behaviour cd.

1. **Merchant Brokering** - combines the 'consideration set' with merchant-specific information to help determine *who* to buy from; this includes the evaluation of merchant alternatives based on consumer-selected criteria.
2. **Negotiation** - this stage is about *how* to determine the terms of the transaction
3. **Purchase and Delivery** - the purchase and delivery of a product can either signal the termination of negotiation stage or occur afterwards.
4. **Service and Evaluation** - this post-purchase stage involves product service, customer service.

CBB Model cont. 2

Agents in the field of e-commerce can be used in the three stages in the framework of their Consumer Buying Behaviour model:

- Product Brokering
- Merchant Brokering
- Negotiation

Systems for Product Brokering

The *Product Brokering* stage of the CBB model is where consumers determine *what* to buy.

Examples of systems that lower consumers' search costs when deciding which product best meet their criteria:

- **PersonalLogic** - tool that enables consumers to narrow down the products that best meet their needs by guiding them through a large product feature space by filtering out unwanted products.
- **Firefly** - helps consumers find products. Instead of filtering products, it recommends them via a "word of mouth" recommendation mechanism.
- **Tete-a-Tete** - discussed later

MERCHANT BROKERING - BARGAINFINDER

The first shopping agent for online price comparisons developed in Andersen Consulting.

HOW DOES IT WORK?

Given a specific product , *BargainFinder* requests its price from merchant Web sites using the same request as from a Web browser.

E-Marketplaces for Product and Merchant Brokering

Examples

- Frictionless Commerce
- Multi-Agent Trading Environment

Frictionless Commerce

- the consumer is given an opportunity to choose what to buy who to buy a certain product from
- users are enabled to search for merchants selling the product based on value, not just price
- online consumers use the Frictionless' Engine to initialize their agents by selecting individualized criteria
- consumers rate their preferences ranging from 'must have' to 'not important'
- consumers' preferences may be vague
- on merchant's side all preferences are crisp
- Frictionless' Engine uses multi-attribute utility theory to rank the crisp proposals coming from the merchants according to the consumer's vague preferences

MATE - Multi-Agent Trading Environment

Difference from *Frictionless Commerce*

Additional **purchasing assistance** and **merchant brokering agents** in the architecture.

Purchasing Assistance

Supports a buyer at:

- **specification stages** - user inputs his preferences and their relative weights using a user interface. User interface specification is connected with product ontology and changes dynamically according to the product under specification. Preferences may be vague.
- **evaluation stages** - the purchasing agent produce a ranking of merchant's offers (evaluation algorithm is derived from multi-attribute utility theory).

Agents in MATE

Merchant's agent

- Every merchant is represented by an agent acting on his behalf on the e-marketplace.
- Functionality:
  - provides user interface for creation and modification of product data
  - automation of process of selecting the product from merchant's database which satisfies buyers criteria and merchant's business goal
  - in MATE fuzzy-logic matching is used

NEGOTIATIONS IN MADE

MADE all merchants' preferences are crisp $\Rightarrow$ no matter to negotiate

REMARK

The process of merchant and product brokering can be considered as '**pre-negotiation' step** i.e. searching for the suitable partners to negotiate.

AUCTIONS

Online auctions - can be regarded as multi-agent e-marketplaces

AGENTS' NEGOTIATION IN AUCTIONS

- EBAY'S AUCTION WEB - English auction, negotiation issue is price
- FISHMARKET AUCTION HOUSE - Dutch auction, negotiation issue is price
- EAUCTION HOUSE - Combinatorial auction, negotiation issues are prices of combination of items
- AUCTIONBOT

When more negotiation issues that just price exist, it is not the right choice to use auctions e.g. in BTB area terms, penalties are even more important than price.

ENGLISH AUCTION - *eBay's Auction Web*

- to sell sth one has to provide a description of an item together with some preferences $\rightarrow$ initialization of an agent to negotiate about one issue (price) with vague preferences (the price should not be less than the reserved price)
- for a bidder, the system offers an optional "phantom" bidding service $\rightarrow$ initialization of buying agent
- a bidder can enter the value of the maximum bid - his only vague preference

DUTCH AUCTION - *Fishmarket*

The academic prototype of an online auction with the old institution of a fish market as the underlying model.

- both agents and human beings can trade there according to downward (Dutch) bidding protocol
- not only market-owned agents with simple architecture and strategies are employed but also **user-encoded buying and selling agents** may compete in the auction through standarized Java agent interface applets
- it is left to users to encode their own bidding strategies
- not currently used as a real-world system, but it has hosted tournaments to compare opponents' hand-crafted bidding strategies

COMBINATORIAL AUCTION - *eAuctionHouse*

Free-to-use online auction that is one of the services of the *eMediator* system.

- supports combinatorial auctions (bidders may place bids on combinations of items) and bidding via software agents

AUCTIONBOT

- *AuctionBot* **users create new auctions** to sell products by choosing from a selection of auction types and specifying its parameters
- *AuctionBot* provides **API** for users to create their own software agents to autonomously compete in the marketplace
- it is left to users to encode their own bidding strategies

MULTI-AGENTS E-MARKETPLACES

AGENT-BASED SYSTEMS FOR NEGOTIATIONS

- *Kasbah* - negotiation through proposals; no critique and counter-proposals; negotiation issue is price; automation of **merchant brokering and negotiation stages** within CBB
- *Tete-e-Tete* - negotiations through proposals, critique and counter-proposals; negotiations issues are price and other value-added services; automation of **product and merchant brokering, negotiation stages** in CBB
- *ZEUS-based e-marketplace* - negotiation through proposals; no critique and counter-proposals; negotiation issue is price

How does it work?

- buyers and sellers can initialize agents by specifying:
  - what they want to buy or sell
  - desired price
  - the highest acceptable price for buyers or lowest acceptable price for sellers
  - the day they want the transaction to be completed
  - negotiation strategy
- after buying and selling agents have been matched:
  - buying agents offer to selling agents their current bids
  - selling agents compare the bids with their current prices and reply with 'yes' if one bid was accepted or 'no' if all bids were rejected
  - in the last situation, in a specified time interval, selling agents lower the prices and buying agents raise the bids according to their negotiation strategies
  - above procedure is repeated until an agreement is

Negotiation strategy in *Kasbah*

Negotiation

The negotiation strategy for selling agent is specified by the **'decay' function** that the agent uses to lower the price over a given time frame. Buying agent is given a **'raise' function** for the bids.
Selling agents have a span from the desired price to the lowest acceptable bid and buying agents have a span from the desired price to the highest acceptable bid.

Bidding strategies for buyers provided by *Kasbah*

- **anxious** - linear function for increasing bid over time
- **cool-headed** - quadratic function for increasing bid over time
- **frugal** - exponential function for increasing bid over time

Tete-a-Tete MARKETPLACE

- Continuation of the *Kasbah* project and a response to the need of multi-issue negotiations.
- Integrates **Product Brokering**, **Merchant Brokering** and **Negotiation stages** of CBB model.
- *Tete-a-Tete* agents cooperatively negotiate across **multiple terms of transactions**.
- Like *Kasbah* this negotiation takes the form of **multi-agent**, **bilateral bargaining** but not using simple raise or decay functions as in *Kasbah*.
- *Tete-a-Tete* agents follow argumentative style of negotiation with sales agents and use the evaluation constraints captured during the Product Brokering and Merchant Brokering stages as dimensions of the **multi-attribute utility**.
- This utility is used by shopping agent to rank merchant offerings.

Tete-a-Tete MARKETPLACE CONT.

Initially it was intended to allow vague preferences on both sides and negotiations with proposals, critique and counter-proposals.

Project was transformed into the *Frictionless Commerce*.

Reasons for the transformation:

- each of the negotiating sides has a different status $\Rightarrow$ multi-issue negotiation with vague preferences is neither practical nor necessary
- the complexity in the negotiation problem is much higher than in *Kasbah* so the solutions from *Kasbah* were not applicable

ZEUS-BASED E-MARKETPLACE

Authors used the *ZEUS Agent Building Toolkit* for implementation of the multi-agent e-marketplace.

Theoretical Approaches to Automated Negotiations

Theoretical approaches to automated negotiations

- game theory based negotiation
- auction based negotiation
- multi-attribute utility theory based negotiation

Game Theory Based Bargaining

In the framework of game theory traditionally two branches are distinguished:

- **cooperative** game theory e.g. coalition formation
- **non-cooperative** game theory e.g. how intelligent individuals interact with one another in an effort to achieve their own goals

Game

One way to describe a **game** is listing the players participating in the game, and for each player listing the alternative choices (strategies) available to that player.
A **play** consist of choosing certain strategies by the players.
An **outcome** of the play is a pair of numbers (for 2 players) representing the utilities of the players.

GAME THEORY BASED BARGAINING CONT.

To determine "rational" outcome the non-cooperative game theory defines the notion of an **equilibrium strategy**. Concepts of equilibrium strategies:

- **Nash equilibrium** - no player can benefit by unilaterally changing his strategy
- **'dominant' strategies** - optimal for all players independent of what the strategies of the other players are

Advantages and drawbacks of game theory based bargaining

Advantages

- Provides a classification of negotiation.
- In many situations, complete mathematical analysis is possible.
- Bargaining with uncertain and vague information can be modeled.

Critical Points

- The notion of equilibrium strategy is not unique.
- Mathematically optimal solution is not always the most suitable one for practice.
- Simplified asumptions are frequently made.

Auction Based Negotiation

The common view among economist is that an auction is the most effective way of resloving "one to many" bargaining problem.

Four basic types of single auctions (single seller):

1. the ascending bid auction (English auction)
2. the descending bid auction (Dutch auction)
3. the first price sealed bid auction
4. the second price sealed bid auction (the Vickrey auction)

Single auctions

English auction

- the buyers raise the bids up to their reservation prices until only one buyer remains
- if buyer maximum bid meets or exceeds the seller's reservation price, the transaction is completed
- all buyers can see high bid and in some cases other buyers' bids

Dutch auction

- the seller starts at a very high price, and then lowers the price continuously
- all buyers can see the current price and then decide if the price is still too high or if their wish to purchase at that price
- the first bidder at the current price wins the auction

SINGLE AUCTIONS CONT.

FIRST PRICE SEALED BID AUCTION

- each buyer independently submits in secret a single bid
- bids are opened simultaneously and the item is sold to the buyer who makes the highest bid
- nobody is allowed to update a bid once submitted
- the winner pays the highest price bid

THE VICKREY AUCTION

- each buyer independently submits in secret a single bid
- bids are opened simultaneously and the item is sold to the buyer who makes the highest bid
- the winner pays the second- highest price bid

Advantages and drawbacks of the auction based negotiation

Advantages

- One-to-many negotiation
- Mathematically optimal strategies can be found both for sellers and for buyers
- Bargaining with uncertain and vague information can be modeled

Critical Points

- One-issue (price) negotiation
- Theoretical results cannot always be applied in practice
- Simplified assumptions are frequently made

Multi-Attribute Utility Theory

Multi-attribute utility theory can be used to rank the crisp proposals coming from the merchants according to consumer's vague preferences.

Elements of multi-attribute utility theory

m - paritcipants number

n - number of negotiation issue each of them of numerical nature

x^i_j - value for issue j offered to the negotiation participant i

$a^i_j \leq x^i_j \leq b^i_j$ - interval of values acceptable by each participant

Multi-Attribute Utility Theory cont.

Scoring function

Different values from participant's interval can be of different worth. The worth of values of negotiation issues is modeled by scoring function:

$S^i_j : [a^i_j, b^i_j] \rightarrow [0, 1]\, j = 1, \ldots, n, i = 1, \ldots, m$

Relative importance

Negotiation issues are of different importance $\Rightarrow$ relative importance is assigned to each issue under negotiation by each participant

ω^i_j - relative importance of issue j for the participant i

Multi-Attribute Utility Theory cont. 2

Negotiation

The negotiation participant i is given an offer.
Negotiation is characterized by n issues $\rightarrow$ offer can be represented by $x = (x_1, \cdots, x_n)$
Linear scoring function can be used to model the utility:
$S^i(x) = \sum \omega^i{}_j S^i{}_j(x)$, $i = 1, \cdots, m$
It is possible to compute the optimum value of x giving theoretical value for the 'best deal'.

Advantages and drawbacks of the multi-attribute utility based negotiation

Advantages

- Many-to-many multilateral negotiation
- For linear scoring functions, optimal value of the 'best deal' can be found
- Bargaining with uncertain and vague information can be modeled

Critical Points

- Scoring functions are problem- and user- dependent
- For non-linear scoring functions, the mathematical analysis is very difficult
- No general recommendations how to construct the negotiations strategies

Summary

- Most multi-agent systems on the Internet use **simple and static negotiation** rules and are designed to **negotiate about the price** and not about the warranties, delivery times, service contracts, return policies and other value-added services.
- Methods and tools to process vague preferences and uncertain information are rarely used.
- The most popular approaches like game theory and auction theory are **hardly useful for modeling of multi-lateral negotiation** about many issues with vague preferences on either negotiating side. Solution to this problem may be using of multi-attribute utility theory.

BIBLIOGRAPHY

- 'Automated Negotiation on Agent-Based e-Marketplaces: An Overview' S.Klaune, K.Kurbel, I.Loutchko, 2001
- 'Agent-mediated Electronic Commerce: A Survey' R.H.Guttman, A.G.Moukas, P.Maes