

BEST PRACTICES AGENT PATTERNS FOR ON-LINE AUCTIONS

Manuel Kolp*, Ivan Jureta*, Stéphane Faulkner⁺

**University of Louvain, Information Systems Unit, Place des Doyens, 1, 1348 Louvain-la-Neuve, Belgium*

⁺*University of Namur, Department of Management Sciences, Rempart de la Vierge, 8, 5000, Namur*

Keywords: Agent patterns, On-line auctions

Abstract: Today high volume of goods and services is being traded using online auction systems. The growth in size and complexity of architectures to support online auctions requires the use of distributed and cooperative software techniques. In this context, the agent software development paradigm seems appropriate both for their modelling, development and implementation. This paper proposes an agent-oriented patterns analysis of best practices for online auction. The patterns are intended to help both IT managers and software engineers during the requirement specification of an on-line auction system while integrating benefits of agent software engineering.

1 INTRODUCTION

The emergence and growing popularity of Internet-based electronic commerce has raised the challenge to explore scalable global electronic market information systems, involving both human and automated traders (Rachlevsky-Reich and al., 1999).

Online auctions are a particular type of Internet-based markets, i.e., worldwide-open markets in which participants buy and sell goods and services in exchange for money. Most online auctions rely on classical auction economics (see e.g., Bikhchandani de Vries, Schummer and Vohra, 2001; Chakravarti and al., 2002; Beam and Segev, 1998). "An auction is an economic mechanism for determining the price of an item. It requires a pre-announced methodology, one or more bidders who want the item, and an item for sale" (Beam and Segev, 1998). The item is usually sold to the highest bidder. An online auction can be defined as an auction which is organized using a software system, and accessible to participants exclusively through a website.

Recently, online auctions have become a popular way to trade goods and services. During 2002, the leading online marketplace, eBay.com, provided a trading platform for 638 million items of all kinds. The value of all goods that were actually traded

amounted to nearly \$15 billion (Ebay, 2002), which represented, at the time, 30% of all online sales in the US. In addition, auctions can be used as underlying economic models for resource management in peer-to-peer and grid computing (Buyya, Stockinger, Giddy and Abramson, 2001), making it possible to deploy patterns in other domains.

This paper proposes an agent-oriented patterns analysis of best practices for online auction. Providing agent-oriented patterns for such systems can reduce their development cost and time, while integrating benefits of agent-orientation in software development. Agent-oriented development is a modern software engineering paradigm for analyzing and designing distributed and dynamic systems (Ramchurn, Huynh and Jennings, 2004) such as online auctions. An agent is an autonomous software entity that is responsive to its environment, proactive (in that it exhibits goal-oriented behavior), and social (in that it can interact with other agents to complete goals) (Mylopoulos, Kolp and Castro, 2001). Multi-agent systems involve the interaction of multiple agents, both software and human, so that they may achieve common or individual goals through cooperative or competitive behavior.

Patterns of best practices in the online auction domain will facilitate the development of new

auction systems, by clearly showing the functional and non functional aspects that are particularly valued by auction participants. Patterns – which are reusable solutions to recurring development problems – for online auction have already been proposed in the literature (see e.g., Re, Braga and Masiero, 2001). However, these patterns have been specified using object-oriented concepts. Consequently, they do not show agents as intentional, autonomous, and social entities. In addition, the patterns usually do not integrate best practices identified in current operating auction systems on the Internet. (Kumar and Feldman, 1998) only provides a global architecture of a basic online auction system in the context of object-oriented software development. GEM (Rachlevsky-Reich B. and al., 1999) provides system architecture for developing large distributed electronic markets but it only addresses the system's basic functionalities required to organize trading among agents. It provides patterns without treating intentional aspects, and uses agents at implementation level.

The rest of this text is organized as follows. Section 2 discusses the *i** agent framework we have used to represent the patterns. Section 3 describes the best practices agent patterns we have analysed in the domain of online auctions. Section 4 concludes the text and discusses some further work of our research.

2 THE *I** FRAMEWORK

In the following, we analyse each pattern using the *i** framework (Yu, 1994). *i** is an agent-oriented modelling framework used to support the early phase of requirements engineering, during which the analyst represents and understands the wider context in which the system will be used. The framework focuses on intentional dependencies that exist among actors, and provides two types of models to represent them: a strategic dependency (SD) model used for describing processes as networks of strategic dependencies among actors, and a strategic rationale (SR) model used to describe each actor's reasoning in the process, as well as to explore alternative process structures.

The main modelling constructs of the *i** framework are Actors, Roles, Goals, Softgoals, Resources, and Tasks (See Figure 1). Both the SD and SR models can represent dependencies among Actors or Roles. A dependency describes an "agreement" (called *dependum*) between two actors: the *dependor* and the *dependee*. The *dependor* is the depending actor, and the *dependee*, the actor who is

depended upon. The type of the dependency describes the nature of the agreement. *Goal* dependencies represent delegation of responsibility for fulfilling a goal; *softgoal* dependencies are similar to goal dependencies, but their fulfilment cannot be defined precisely; *task* dependencies are used in situations where the dependee is required.

Actors are represented as circles; dependums – goals, softgoals, tasks and resources – are respectively represented as ovals, clouds, hexagons and rectangles; dependencies have the form *dependor* → *dependum* → *dependee*.

In *i**, software agents are represented as Actors. Actors can play Roles. A Role is an abstract characterization of the common behaviour of an Actor in some specific context (e.g., a consumer, a salesman, a buyer, a seller, etc.).

3 BEST PRACTICES PATTERNS

Online auctions are highly dynamic processes which involve numerous participants. Their structure changes rapidly to reflect the entry and exit of bidders as well as the impact of their behaviour on the price of the item being auctioned. The most common mechanism for on-line sales are the "English", "Vickrey", "Dutch", and "first-price sealed bid" auctions (Beam and Segev, 1998; Papazoglou, 2001). We briefly describe them below.

English Auction. Each bidder sees the highest current bid, can place a bid and update it many times. The winner of the auction is the highest bidder who pays the price bid, i.e. the final auction bid that this bidder placed. An example is eBay.com (Ebay, 2004). English auctions are by far the most popular auction type and their success lies most probably in the familiarity of English auctions as well as in the entertainment they provide to participants (in the form of bidder competition) (Beam and Segev, 1998).

First-Price Sealed Bid Auction: Each bidder makes a single secret bid; the winner is the highest bidder, and the price paid is the highest bid. An example is The Chicago Wine Company (tcwc.com).

Vickrey Auction: Each bidder makes a single secret bid; the winner is the highest bidder. However, the price paid is the amount of the second highest bid. Some online auction systems propose it as an option (e.g., iauction.com).

Dutch Auction: The seller steadily lowers the price of the item over time. The bidders can see the current price and must decide if they wish to purchase at that price or wait until it drops further.

The winner is the first bidder to pay the current price. An example is klik-klok.com.

Today's online auction offer features more complex to those that automate the traditional auction mechanisms (e.g. user authentication, auction setup, auction item search, bidding, ... (Re, Braga and Masiero, 2001, Wurman, 2003). In addition to enhancing the user experience, these additional features are essential to the commercial success of an online auction. This paper focuses on best practices to better understand and build these features. The analysis is applicable on any type of auction as far as the participant type is concerned: both the seller and buyer may be either customer and/or business. It is independent of the auction mechanism (english, vickrey, dutch, ...), as long as it involves a single seller and many buyers.

Some of the features can be introduced in the system in several ways, requiring comparison and evaluation. To select the most adequate alternative, we represent relevant system qualities (e.g., security,

privacy, usability, etc.) as softgoals and use contribution links to show how these softgoals are affected by each alternative, as in the Non-Functional Requirements framework (Chung, Nixon, Yu and Mylopoulos, 2000).

Proxy Bidding. Online auctions can last for several days, making it impossible for human buyers to follow the auction in its integrity, as is the case in traditional ones. Proxy bidding allows buyers to specify their maximum willingness to pay. A procedure is then used to automatically increase their bid until the specified maximum is reached, or the auction is closed (Wurman, 2003, Kurbel K. and Loutchko I., 2001). Proxy bidding can be introduced in the basic online auction in several ways in terms of responsibility assignment. Two alternatives are shown in Figure 1.

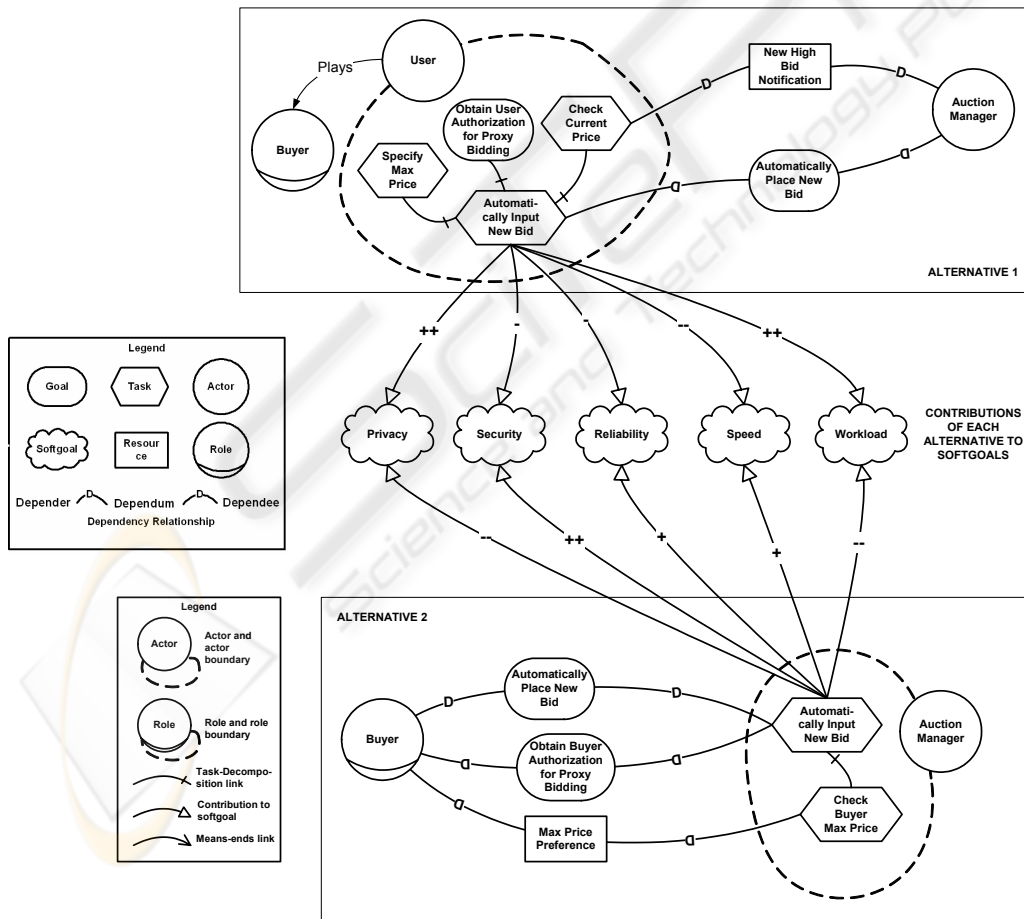


Figure 1: Two alternative responsibility assignments of the Proxy Bidding. Positive (favorable) (+) and negative (not favorable) (-) contributions of each alternative structure aid in selection

Each one is represented as a simple Strategic Rationale model. A series of softgoals have been selected as criteria for alternative comparison – *Privacy, Security, Reliability, Speed, and Workload*. These are non-functional requirements (Chung, Nixon, Yu and Mylopoulos, 2000) for the information system and have been selected according to issues often raised in e-commerce system design (e.g., (Mylopoulos, Kolp and Castro, 2001), online auction design (e.g., Wurman, 2003; Kumar and Feldman, 1998), etc.

The first alternative seems more adequate. The responsibility of managing proxy bidding is allocated to the *Buyer* agent. Several reasons support this choice:

- When the *Buyer* manages proxy bidding, price preferences are not communicated to outside agents. Consequently, *Privacy* is higher than in the second alternative which requires the transfer of price preferences to the *Auction Manager*.
- *Workload* of the system is lower, since automatic bidding is distributed among multiple *Buyer* agents participating in the auction. We consider that system *Workload* is much higher when all proxy bidding activity in one auction is centralized at the *Auction Manager*.
- We consider that *Security* of data transfers between the *Buyer* and *Auction Manager* is not of high priority in an English online auction, since the bid made by the *Buyer* is made publicly available by the *Auction Manager*.

Reliability concerns the probability of error in terms of e.g., a new proxy bid not being taken into account by the *Auction Manager*. This probability is higher when proxy bidding is distributed among multiple *Buyers*. Finally, it is probable that speed of bid input is higher when proxy bidding is centralized, since there are no data transfers between the *Auction Manager* and *Buyer* agents.

Based on this discussion, we select the first alternative on Figure 1. Consequently, proxy bidding is introduced in the system as a service that a *User* agent playing *Buyer* role can provide to the human user, and requires the human user to specify the maximum price that he/she is willing to pay. In addition, the *Buyer* agent needs to obtain an authorization from the user in order to initiate proxy bidding.

Reputation management. In classical exchanges where buyers and sellers actually meet, trust results from repeated buyer-seller interactions, from the possibility to inspect items before the purchase, etc. In online auctions, sellers and buyers do not meet, and little personal information is publicly available

during the auction. In addition, product information is limited to information provided wilfully by the seller. In such a context, a mechanism for managing trust should be provided in order to reduce uncertainty in transactions among auction participants.

According to (Ramchurn, Huynh and Jennings, 2004), “trust is a belief an agent has that the other party will do what it says it will (being honest and reliable) or reciprocate (being reciprocative for the common good of both), given an opportunity to defect to get higher payoffs.” Trust can be favoured in an on-line auction through a reputation mechanism, which should satisfy specific requirements (Ramchurn, Huynh and Jennings, 2004): it should be costly to change identities in the community; new entrants should not be penalised by having a initial low reputation rating; participants with low ratings should be able to rebuild reputation; it should be costly for participants to fake reputation; participants with high reputation should have more influence on reputation ratings they attribute to other participants; participants should be able to provide more qualitative evaluations than simply numerical ratings; and finally, participants should be able to keep a memory of reputation ratings and give more importance to the latest ones. Such reputation mechanism can reduce the hesitancy of new buyers and sellers when using the online auction for the first time, as it implicitly reduces the anonymity and uncertainty among trading partners.

It is difficult to construct a reputation system that satisfies all of these requirements. Seller reputation can be established through feedback of buyers on the behaviour of sellers during the trade settlement which follows the closure of the auction (Ebay, 2002; Resnick and Zeckhauser, 2002). As a result of buyer feedback in repetitive sales, a seller receives a rating which is indicative of the trust that the trading community has in him/her.

In order to enable the management of trust in the on-line auction, we introduce in Figure 2 an additional agent: *Reputation Manager*, which is a specialization of the *Information Brokering Agent* (Papazoglou, 2001). Informally, its responsibility is to collect, organize, and summarize reputation data. The *Reputation Manager* depends on the winning *Buyer* of each auction to provide feedback on the *Seller* after the trade settlement. *Reputation Manager* uses *Qualitative* (textual) and *Quantitative* (numerical) *Feedback on Seller* to establish reputation ratings of *Users* that have played the role of *Sellers* in auctions. As information on reputation is valuable to any *User* of the on-line auction, any *User* depends on the *Reputation Manager* to *Manage Feedback Forum*, in which the feedback

and rating information is contained and organized. Each *Buyer* depends on the *Reputation Manager* to provide summarized *Seller Reputation Information*, so that the *Buyer* can have an indication on the trust he/she can put into the relationship with the *Seller*. The *Seller* can post replies on feedback provided by *Buyers*. Finally, the *Seller* depends on the *Reputation Manager* to *Manage Reputation Rating*.

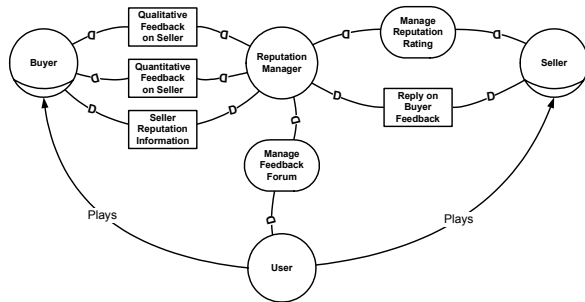


Figure 2: Reputation Management pattern

This pattern satisfies all but one of the requirements specified above: it does not make it costly for participants to change identities. For example, eBay (Ebay, 2004) deals with this problem by requiring each seller to provide a valid credit card number.

Dispute Resolution (Figure 3). The trade settlement that follows the closure of the auction may not be successful for many reasons (e.g., late deliveries, late payment, no payment). It then results in dispute that can require mediation by a third party in order to be resolved. It (here, a *Negotiation Assistant*) can be a software agent that manages an automated dispute resolution process or a human mediator (Squaretrade, 2004).

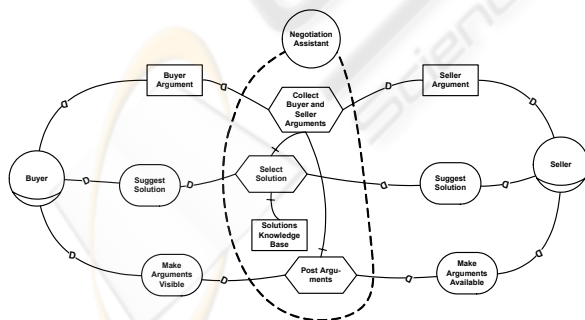


Figure 3: Strategic Rationale model of the Dispute Resolution pattern with focus on *Negotiation Assistant* agent rationale

The *Negotiation Assistant* collects *Buyer* and *Seller Arguments*, and makes them available to both parties. On the basis of these *Arguments* and its

Solution Knowledge Base, the agent *Selects Solution* – both the *Buyer* and the *Seller* depend on the agent to *Suggest Solution* to their dispute.

Payment. Payment can be accomplished in numerous ways in the context of an online auction. They can be either managed (in part) through the online auction – e.g., credit card based transactions –, or outside the scope of the online auction information system (OASIS) – e.g., cash, checks, etc. The payment choice of auction participants is not repetitive and differs according to the payment cost, convenience, and protection (Li, Ward and Zhang, 2003).

In the Payment pattern, the *Payment Agent* (specialization of the *Negotiating and Contracting Agent* (Papazoglou, 2001)) mediates the payment interaction between the *Seller* and the *Buyer*. This agent depends on the *Account Manager* for data on *Users*, which is then used in providing *Payment Details* to the *Payment System*. In addition to user identification, *Payment Details* should also contain transaction-related data. The *Payment Agent* depends on the *Payment System* to *Realize Payment* and to provide *Money Transfer Confirmation*, which is used to *Confirm Money Transfer* to the *Seller*. The *Payment System* is outside the boundary of the online auction. Upon closure of the auction, the *Seller* depends on the *Payment Agent* to *Invoice Buyer*. The *Buyer* depends on the *Payment System* to provide *Invoice* and in return, the *Buyer* is expected to *Authorize Transfer*. The pattern structure in Figure 4 is adapted to PayPal (Paypal, 2004) and all common credit card based payment systems. Any of these payment systems intervenes in the pattern as the *Payment System* specialized in money transfers.

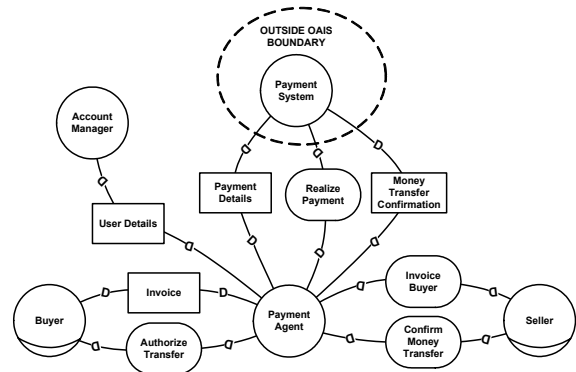


Figure 4: Payment pattern

4 CONCLUSION

Online auctions have become increasingly popular in e-business transactions (Wurman, 2003). Companies require such systems to be developed on tight budgets and in short time, in order to deploy auctions in managing relationships with their suppliers and clients. Patterns of best practices of online auctions can provide significant aid in the development process of such systems.

This paper explores such patterns, by analysing some advanced online auctions functionalities through the lens of the agent paradigm. Compared to the literature, our approach is innovative in several respects: we consider that multi-agent systems are particularly adapted to modelling and implementing online auction systems; we provided the i^* agent-oriented modelling perspective of each pattern we consider and we focused on specifying best practices in current online auction systems.

There are limitations to our work. We have not provided other dimensions than the i^* (social and intentional) ones for the patterns. This is well beyond the scope of this paper as it requires much more time and space. As future work, the patterns will be modelled using UML-based notations as well as formally specified with the Z language.

REFERENCES

- Amazon (2004). <http://www.amazon.com>.
- Beam C. and Segev A. (1998) *Auctions on the Internet: A Field Study*. Working Paper 98-WP-1032, University of California, Berkeley, USA.
- Bikhchandani S., de Vries S., Schummer S. and Vohra R.V. (2001) "Linear Programming and Vickrey Auctions". In Dietrich B., Vohra R.: *Mathematics of the Internet: E-auction and Markets*. Springer.
- Buyya R., Stockinger H., Giddy J. and Abramson D. (2001) "Economic Models for Management of Resources in Peer-to-Peer and Grid Computing", In *SPIE International Symposium on The Convergence of Information Technologies and Communications* (ITCom 2001), Denver, USA.
- Chakravarti D., and al. (2002). "Auctions: Research Opportunities in Marketing". *Marketing Letters* 13, 281–296.
- Chung L.K., Nixon B.A., Yu E. and Mylopoulos J. (2000) *Non-Functional Requirements in Software Engineering*. Kluwer.
- Ebay (2002) *Ebay 2002 Annual Report*, <http://www.ebay.com>.
- Ebay (2004) <http://www.ebay.com>.
- Kumar M. and Feldman S.I. (1998) "Internet Auctions" *Proceedings of the 3rd USENIX Workshop on Electronic Commerce*, Boston.
- Kurbel K. and Loutchko I. (2001) "A Framework for Multi-agent Electronic Marketplaces: Analysis and Classification of Existing Systems". *Proceedings of International Congress on Information Science Innovations* (ISI'2001), Dubai, U.A.E.
- Li H., Ward R. and Zhang H. (2003) *Risk, Convenience, Cost and Online Payment Choice: A Study of eBay Transactions*. Georgia Institute of Technology Working Paper.
- Mylopoulos J., Kolp M. and Castro J. (2001) "UML for Agent-Oriented Software Development: The Tropos Proposal". *Proceedings of the Fourth International Conference on the Unified Modeling Language* (<<UML>> 2001), Toronto, Canada.
- Papazoglou M.P (2001) "Agent-Oriented Technology in Support of E-Business". *Communications of the ACM* 44-4, pp. 71-77.
- Paypal (2004) <http://www.paypal.com>.
- Rachlevsky-Reich B. and al. (1999) "GEM: A Global Electronic Market System". In *Information Systems* 24, pp. 495-518.
- Ramchurn S.D., Huynh D. and Jennings N.R. (2004) "Trust in Multi-Agent Systems". *The Knowledge Engineering Review*.
- Re R., Braga R.T.V. and Masiero P.C. (2001) "A Pattern Language for Online Auctions Management". *Proceedings of the 8th Conference on Pattern Languages of Programs* (PLoP'2001).
- Resnick P. and Zeckhauser R. (2002) "Trust Among Strangers in Internet Transactions: Empirical Analysis of eBay's Reputation System". In Michael R. Baye (ed.) *Economics of the Internet and E-Commerce*, Elsevier.
- Squaretrade (2004) <http://www.squaretrade.com>.
- Wurman P.R. (2003) "Online Auction Site Management". In *The Internet Encyclopedia*, <http://www.csc.ncsu.edu/wurman/Wur-article.pdf>
- Yahoo (2004) <http://auctions.shopping.yahoo.com>.
- Yu E. (1994) *Modelling Strategic Relationships for Process Reengineering*. Ph.D. thesis, Dept. of Computer Science, University of Toronto.