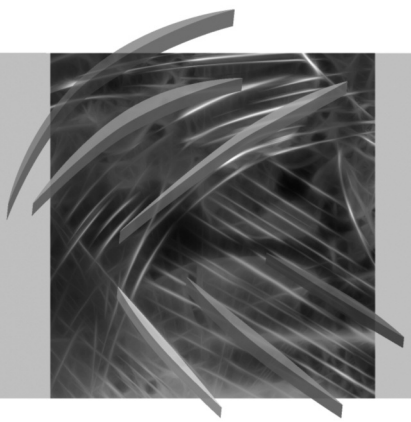
PRACE NAUKOWE
Uniwersytetu Ekonomicznego we Wrocławiu
RESEARCH PAPERS
of Wrocław University of Economics

232

Knowledge Acquisition and Management



edited by
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Publishing House of Wrocław University of Economics
Wrocław 2011

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Information on submitting and reviewing papers is available
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ISSN 1899-3192
ISBN 978-83-7695-200-0

The original version: printed

Printing: Printing House TOTEM

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PRACE NAUKOWE UNIWERSYTETU EKONOMICZNEGO WE WROCŁAWIU nr 232
RESEARCH PAPERS OF WROCŁAW UNIVERSITY OF ECONOMICS
Knowledge Acquisition and Management ISSN 1899-3192

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MULTI-AGENT SYSTEM FOR ELECTRONIC AUCTIONS

Summary: The main advantage of the introduction of electronic business (EB) is reducing the cost and speed of the implementation of business processes as well as providing more convenient services to customers. Agent-oriented technology (AOT) is applied to meet these challenges successfully. In this paper the author presents the possibility of applying agent-oriented approach to a creation of multi-agent system of electronic auctions, as well as the implementation of this software using the agent system JADE.

Keywords: e-business, JADE, Agent system.

1. Introduction

There is a growing interest in scientific methods of effective management of an enterprise associated with the desire to optimise its operations. The rapid expansion of e-business has become an economic manifestation of the formation of a new innovative information society, whose development is largely dependent on information, knowledge, and education. The scope and level of information and communication technologies are the important factors affecting the ability of enterprises to quickly and successfully adapt to changes in the surrounding business.

The main advantage of the introduction of electronic business (EB) is reducing the cost and speed of the implementation of business processes as well as providing more convenient services to customers. However, when comes to using EB systems, today there is a lack of real automation of many tasks. To meet these challenges successfully, agent-oriented technology (AOT) is applied. It is based on the use of intelligent software agents and allows increasing the functionality of modern distributed systems. AOT is an integrated technology that uses a variety of sources and concepts: decision theory, distributed systems, object-oriented technology, the theory of organisations, systems of knowledge bases.

The aim of this research is to study multi-agent systems, the possibility of applying agent-oriented approach to a task – the creation of multi-agent system of an electronic auction, as well as the implementation of this software using the agent system JADE. Using intelligent agents can provide an individual approach to each

customer. In addition, the use of multi-agent approach will improve the reliability through electronic companies in the form of a system with distributed artificial intelligence.

2. The agents paradigm

A multi-agent system (MAS) is a system composed of multiple interacting intelligent agents. Multi-agent systems can be used to solve problems which are difficult or impossible for an individual agent or a monolithic system to solve. The examples of problems which are appropriate to multi-agent systems research include online trading, disaster response, and modeling social structures.

The agents paradigm applies concepts from artificial intelligence and speech act theory to the distributed object technology. The paradigm is based on the agent abstraction, a software component that is autonomous, proactive, and social.

The term agent is very broad and has different meanings to different people. However, on close observation of the literature, it is sufficient to say that two usages of the term agent can be identified: the weak notion of agency and the strong notion of agency [Vidal 2010]. The weak notion of agency constitutes the bare minimum on which most research studies agree, while the stronger notion of agency is more controversial and a subject of active research. The weak notion of agency denotes a software-based computer system with the following properties [Vidal 2010]:

- **Autonomy:** agents operate without the direct intervention of humans or others and have some kind of control over their actions and internal state.
- **Social ability:** agents interact with other agents (and possibly humans) via some kind of agent communication language.
- **Reactivity:** agents perceive their environment and respond in a timely fashion to changes occurring therein.
- **Pro-activeness:** in addition to acting in response to their environment, agents are able to exhibit goal-directed behavior by taking initiative.

The strong notion of agency is an extension of the weaker notion and advocates additional humanistic, mental properties such as belief, desire, and intention [Vidal, Durfee 2003]. The JADE methodology assumes the following definition for an agent: “agents reside on a platform that, consistent with the presented vision, provides the agents with a proper mechanism to communicate by names, regardless of the complexity and nature of the underlying environment (i.e. operating systems, networks, etc)”.

Consider the main features of intelligent agents. Agents, by definition, are able to perceive their environment. This automatically leads to the fact that an agent is a model of the external world. The more complex the model, the more information agents can use in their work. Agents possessing this property are classified as reflexive agents, based on the model. Agents (or group of agents) have the objective: the expected results to be achieved by solving the challenges that they face. The system

of goals for an agent can also be very difficult. Objectives can be set from outside agent or generated as a result of some agent's "mental activity". Agents possessing this property are classified as reflexive agents based on the target. To achieve goals, an agent can perform certain actions in the environment. Therefore, an agent must have knowledge of the set of their possible actions necessary conditions for their occurrence and possible consequences. Agents must be able to determine the state of the environment, a more preferable than others (having a higher utility). Utility function displays the status of the environment on a real number, which indicates the degree of satisfaction with an agent. Using the utility function, an agent may decide in the case of conflict goals, or if none of the goals can be achieved with certainty. An agent acts in a way that it can reach the best expected outcome. These agents are classified as agent-based utility. A new class of intelligent agents are enrolled agents. The architecture of an agent of this class can provide a learning and productive components. Training component is responsible for making improvements to the model of the world, and the productive component provides a choice of external actions. An artificial agent can only be realised in the form of a programme (softbot, bot) or have hardware and software implementation (robot).

3. Auction theory

There are times when there are many agents and the only thing that they need to negotiate over is price. In these occasions it makes sense to use an auction since they are fast and require little agent communication. However, auctions are not as simple as they might appear first and there are many ways in which things can go wrong when using them.

The actual mechanisms used for carrying out an auction are varied. The most common of all is the English auction. This is first-price open-cry ascending auction. It is the standard one used in most auction houses. In this kind of auction, an auctioneer raises a price as people yell higher bids. Once no-one is willing to bid higher, the person with the highest bid gets an item and pays his or her bid price. These auctions sometimes have an initial or reservation price below which a seller is not willing to sell. The dominant strategy in the **English auction**, with private value, is to bid the current price plus some small amount until either an auction is won or one's reservation price is reached [Vickrey 1962]. If the English auction is common or correlated value, then it suffers from the winner's curse.

A similar auction type is the **first-price sealed-bid auction**. In this auction each person places his or her bid in a sealed envelope. These are given to an auctioneer who then picks the highest bid. The winner must pay his or her bid amount. These auctions have no dominant strategy. The buyer's best strategy is to spy on other bidders in order to determine what they are going to bid and then bid slightly higher than that as long as that is less than one's reservation price. If spying is impossible,

then an agent has no clearly superior strategy. Because of the incentive for spying, these auctions lead to a lot of inefficiencies when paired with intelligent agents.

The **Dutch auction** is an open-cry descending price auction. In this kind of auction, a seller continuously lowers the selling price until a buyer hits a buzzer, agreeing to buy at his or her current price. The analysis of the Dutch auction shows that it is equivalent to a first-price sealed-bid auction in terms of strategy. That is, it has no dominant strategy. However, it has the nice property of being real-time efficient. The auction closes quickly and an auctioneer can make it move even faster by lowering a price faster. This real-time efficiency makes it a very attractive auction for selling cut flowers as these lose their value quickly after being harvested [Vickrey 1962].

Finally, the **double auction** is a way of selling multiple units of the same item. It is the auction used on stock markets. Each buyer places either a buy or a sell order at a particular price for a number of instances of the item (number of shares on the stock-market).

At which auctions do sellers make more money? All four single-item auctions produce the same expected revenue in private value auctions with bidders that are risk-neutral. We also know that if bidders are risk-averse, then the Dutch and first-price auctions are better. A risk-averse bidder is willing to pay a bit more than their private valuation in order to get the item. In the Dutch or first-price auction, a risk-averse agent can insure himself or herself by bidding more than would be required. In common or correlated value cases, the English auction gives higher revenue to a seller [Vickrey 1962]. The increasing price causes others to increase valuation, that is, once an agent sees others bidding very high for an item, the agent realises that an item is really worth more to other agents so it also raises its valuation.

4. Designing and implementation

4.1. Environment

JADE is the middleware developed by TILAB for the development of distributed multi-agent applications based on the peer-to-peer communication architecture. The environment can evolve dynamically with peers, which in JADE are called agents, which appear and disappear in the system according to the needs and the requirements of the application environment. Communication between peers, regardless of whether they are running in the wireless or wire line network, is completely symmetric with each peer being able to play both an initiator and a responder role. JADE is fully developed in Java and is based of the following driving principles (see [JADE 2010]):

– **Interoperability:** JADE is compliant with the FIPA specifications. As a consequence, JADE agents can interoperate with other agents provided that they comply with the same standard.

- **Uniformity** and **portability:** JADE provides a homogeneous set of APIs that are independent from the underlying network and Java version. More in details, the JADE run-time provides the same APIs both for the J2EE, J2SE, and J2ME environment. In theory, application developers could decide the Java run-time environment at deploy-time.
- **Easy to use:** the complexity of the middleware is hidden behind a simple and intuitive set of APIs.
- **Pay-as-you-go** philosophy: programmers do not need to use all the features provided by the middleware. The features that are not used do not require programmers to know anything about them, neither adds any computational overhead.

From the functional point of view, JADE provides the basic services necessary to distributed peer-to-peer applications in the fixed and mobile environment. JADE allows each agent to dynamically discover other agents and to communicate with them according to the peer-to-peer paradigm. From the application point of view, each agent is identified by a unique name and provides a set of services. It can register and modify its services and/or search for agents providing given services; it can control its life cycle and, in particular, communicate with all other peers. Agents communicate by exchanging asynchronous messages, a communication model almost universally accepted for distributed and loosely-coupled communications, i.e., between heterogeneous entities that do not know anything about each other. In order to communicate, an agent just sends a message to a destination. Agents are identified by a name (no need for the destination object reference to send a message) and, as a consequence, there is no temporal dependency between communicating agents. A sender and a receiver could not be available at the same time. Despite this type of communication, security is preserved since, for applications that require it, JADE provides proper mechanisms to authenticate and verify "rights" assigned to agents. When needed, therefore, an application can verify the identity of a sender of a message and prevent actions not allowed to perform (for instance, an agent may be allowed to receive messages from the agent representing a boss, but not to send messages to it). All messages exchanged between agents are carried out within an envelope including only the information required by the transport layer. This allows, among others, encrypting the content of a message separately from an envelope. The structure of a message complies with the ACL language defined by FIPA (see [FIPA 2010]) and includes fields, such as variables indicating the context which a message refers to and timeout that can be waited before an answer is received, aimed at supporting complex interactions and multiple parallel conversations. To further support the implementation of complex conversations, JADE provides a set of skeletons of typical interaction patterns to perform specific tasks, such as negotiations, auctions, and task delegation. To facilitate the creation and handling of messages content, JADE provides support for automatically converting back and forth between the format suitable for content exchange, including XML and RDF, and the format

suitable for content manipulation (i.e., Java objects). This support is integrated with some ontology creation tools, e.g., Protege, allowing programmers to graphically create their ontology. To increase scalability or also to meet the constraints of environments with limited resources, JADE provides the opportunity of executing multiple parallel tasks within the same Java thread. Several elementary tasks, such as communication, may then be combined to form more complex tasks structured as concurrent Finite States Machines.

4.2. System architecture

In this research there was a plan to create a multi-agent system of an electronic auction. The main purpose of the system is the organisation of interaction between agents-sellers and agents-buyers, whose interests are coincided. This system belongs to a class of models based on competition. Bidding in the shop will be closed on the scheme of the Dutch type of auction. Agents-sellers seek to sell their goods at the highest possible price and agents-buyers seek to buy the right product at the lowest possible price. Both types of agents operate autonomously. System registers appearance and disappearance of agents and arranges contacts between them. The behaviour of an agent-seller is based on the following parameters:

– description of goods;
– the desired date before which a seller wants to sell goods;
– the price at which he or she wants to sell goods;
– the lowest acceptable price, below which goods are not sold;
– function to reduce a price over time (linear, quadratic, etc.).

The behaviour of an agent-buyer is characterised by the following parameters:

– description of purchased goods;
– deadline for purchase of goods;
– the highest price at which he or she can buy goods;
– function of growth rates over time.

All agents are registered in the system before they begin to interact. Sellers advertise their products in the system, while buyers request the system to search for potential vendors. As soon as seller-agents and buyer-agents are presented to the system, they begin to communicate independently.

Each buyer-agent receives the title of the commodity to buy (the “target commodity”) as a command line argument and periodically requests all known seller-agents to provide an offer. As soon as an offer is received, a buyer-agent accepts it and issues a purchase order. If more than one seller-agent provides an offer, a buyer-agent accepts the best one (lowest price). Having bought the target commodity, a buyer-agent terminates. Each seller-agent has a minimal GUI by means of which a user can insert new commodities (and the associated price) in the local catalogue of goods for sale. Seller-agents continuously wait for requests from buyer-agents.

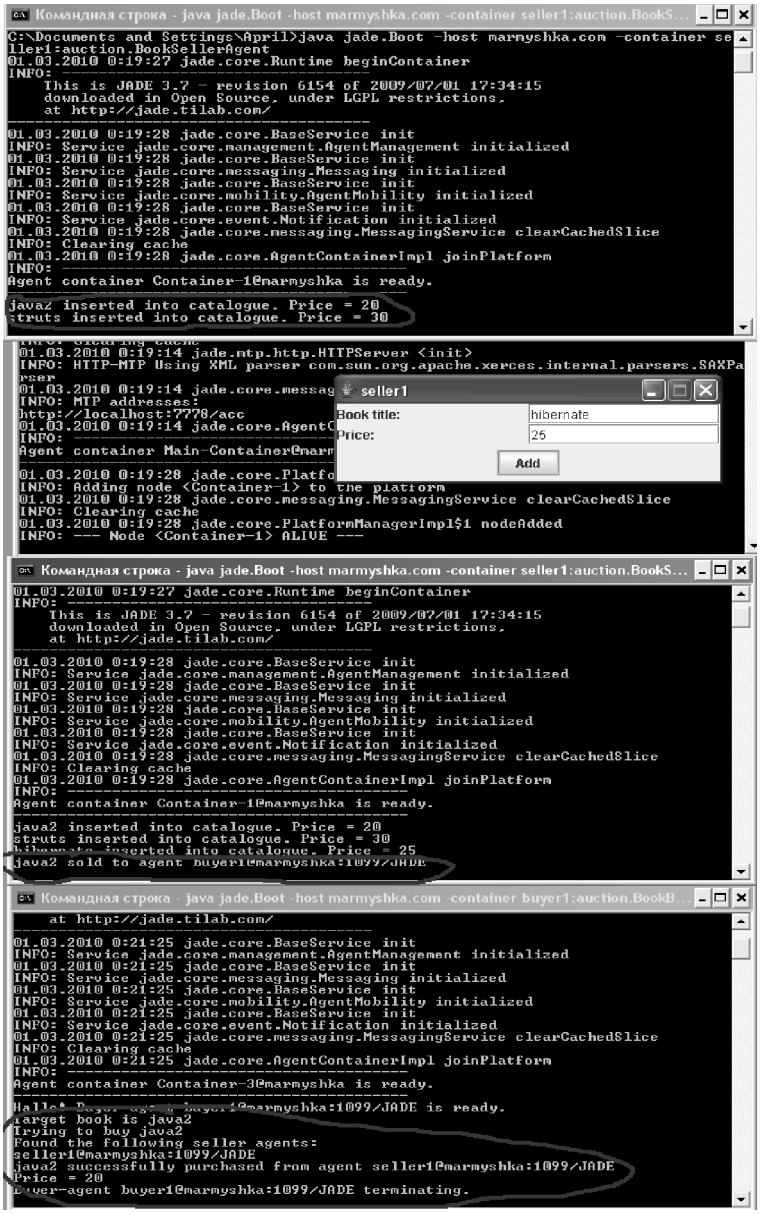

Figure 1. Screen captures showing system in action

Source: author's own study.

When asked to provide an offer for goods, they check if the requested goods is in their catalogue and in this case reply with a price. Otherwise they refuse. When they receive a purchase order, they serve it and remove the requested goods from

their catalogue. All issues related to electronic payment are outside the scope of this research and are not taken into account.

A negotiation problem is the one where multiple agents try to come to an agreement or deal. Each agent is assumed to have a preference over all possible deals. The deal agents send messages to each other in the hope of finding a deal that all agents can agree on. These agents face an interesting problem. They want to maximise their own utility, but they also face the risk of a break-down in negotiation or expiration of a deadline for agreement. As such, each agent must negotiate carefully, trading any utility it gains from a tentative against a possibly better deal or the risk of a breakdown in negotiation.

5. Summing-up

Agent-based systems technology has generated lots of excitement in recent years because of its promise as a new paradigm for conceptualizing, designing, and implementing software systems.

The goal of multiagent systems' research is to find methods that allow building complex systems composed of autonomous agents who, while operating on local knowledge and possessing only limited abilities, are nonetheless capable of enacting the desired global behaviours. Multiagent systems approach the problem, using the well proven tools from game theory, economics, and biology. It supplements these with ideas and algorithms from artificial intelligence research, namely planning, reasoning methods, search methods, and machine learning. Auctions are a common and simple way of performing resource allocation in a multiagent system. At an auction, agents can express how much they want a particular item via their bid and a central auctioneer can make the allocation based on these bids. Obviously, this generally requires the use of a centralised auctioneer, but there are techniques for reducing this bottleneck. Still, even centralised auctions can be very complex and produce unexpected results if one does not understand all the details.

So far the system has worked as a simple online store and the auction scheme has not been completed. We plan in the future to change agents' behaviour and implement the scheme of the Dutch auction. Thus, sellers will be able to accept an offer or make an alternative proposal, pointing to another desired amount. An agent-buyer will be able to increase a price during negotiations, based on his or her well-known function of growth rates over time. At the same time, an agent-seller will query the availability of potential buyers. Then he or she interrogates them with a view to concluding a transaction. The deal is with the agent-buyer who is willing to pay the requested amount. An agent-seller may offer an initial price or lower it based on his or her well-known function of the price reduction over time.

References

Vidal J.M. (2010), *Fundamentals of Multiagent Systems with NetLogo Examples*, http://jmvidal.cse.sc.edu/papers/mas.pdf.

Vidal J.M., Durfee E.H. (2003), Predicting the expected behavior of agents that learn about agents: the CLRI framework, *Autonomous Agents and Multi-Agent Systems*, Vol. 6, Issue 1.

Vickrey W. (1962), Auction and bidding games, [in:] *Recent Advances in Game Theory*, Princeton University Conference.

FIPA (2010), *The Foundation for Intelligent Physical Agents*, http://www.fipa.org.

JADE (2010). *Java Agent Development Framework*, http://jade.cselt.it.

Weyns D., Schumaher M., Ricci A. (2005), *Environments in Multiagent Systems*, Cambridge University Press, Cambridge.

Sierra C. (2004), Agent-mediated electronic commerce, *Autonomous Agents and Multi-Agent Sytems*, Vol. 9.

Roggero D., Patrone F., Mascardi V. (2005), *Designing and Implementing Electronic Auctions in a Multiagent System Environment*, University of Genova.

Sycara K.P. (1998), Multiagents systems, *AI Magazine*, Vol. 19.

Vidal J.M. (2004), *The Past and Future of Multiagents Systems*, University of South Carolina.

DeLoach S.A. (1999), *Multiagent Systems Engeneering. A Methodology and Language for Designing Agents Systems*, Air Force Institute of Technology.

WIELOAGENTOWY SYSTEM WSPIERAJĄCY AUKCJE ELEKTRONICZNE

Streszczenie: Głównymi zaletami wdrażania systemów handlu elektronicznego jest redukcja kosztów, szybkość implementacji procesów biznesowych oraz zapewnienie klientowi wygodnego dostępu do usług. Technologia agentowa jest używana, aby podejmować te wyzwania z sukcesem. W niniejszym artykule autor prezentuje możliwość tworzenia systemu wieloagentowego wspierającego aukcje elektroniczne jako systemu stworzonego przy użyciu platformy programowej JADE.

Słowa kluczowe: handel elektroniczny, JADE, systemy agentowe.