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Leszek Kie??tyka
Cz??stochowa University of Technology

Rafa?? Niedba??
Cz??stochowa University of Technology

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Leszek Kiełtyka
Department of Management Information Systems
Management Faculty
Częstochowa University of Technology
Al. Armii Krajowej 19B
42-200 Częstochowa, Poland
lekiel@zim.pcz.czest.pl,

Rafał Niedbał
Department of Management Information Systems
Management Faculty
Częstochowa University of Technology
Al. Armii Krajowej 19B
42-200 Częstochowa, Poland
rniedbal@zim.pcz.czest.pl

ABSTRACT

The aim of this paper is to present an agent approach in negotiation process modelling in virtual environment of enterprise management. The applied methodological system addresses negotiations of integrative nature. On the basis of literature studies concerning theory of enterprise management in virtual environment, business negotiations theory in conditions of digital economy, theory of systems and optimization as well as conducted surveys *"E-negotiations in Polish enterprises"*, a simulation model of negotiation process is presented. *AgentBuilderPro1.4*® software of *Acronymics, Inc*. was chosen to be the simulating environment. Criteria for evaluating negotiating packages as well as the mechanism of generating compromise solutions by software agents Pareto-optimum are explained.

Keywords

Integrative negotiations, virtual management environment, software agent, agent system, simulating model, Pareto-optimum compromise.

INTRODUCTION

A successive automation of business processes, that is assigning certain fragments of business processes to be carried out by software, may be observed in the contemporary enterprises. Knowledge and technology development in the range of management processes computerization and man-created virtual information environment influenced development of methods facilitating, among others, processes of: production planning, advertising, order placing, invoicing, payment, accounting, etc. Due to the fact, that globalization of the economy forces constant communication among market participants and this in turn leads to more frequent negotiations, the automation of business processes makes it an interesting subject of research. The possibility of their automation and running them in the virtual environment could directly increase effectiveness of enterprise's operation.

The literature concerning negotiation is very extensive. However, it mainly focuses on traditional negotiations – based on giving practical advice for negotiators. There is no formalized approach applying the model of business negotiations automation. However, formalization of negotiation process is a complex task – which is caused by the large participation of a human factor. Negotiations in electronic business are easier in respect of formalization. They concern negotiations – in the virtual management environments – of enterprises with suppliers and customers upon, among others, prices, quantity, kind and quality of products, delivery conditions and terms, ways of payment, guarantee conditions, discounts, profit margin, promotional activities, etc.

Basic issues concerning agent modelling are presented in the first chapter of this paper. There are basic features of a software agent illustrated in it, as well as the advantages of the applied approach.

The second chapter describes the applied methodological set and specified character of the modelled negotiations.

General assumptions and the proposed structure of the simulation model – on the basis of the conducted literature study and survey – are presented in the third chapter of this paper. The criteria for evaluation of negotiated packages and mechanism of generating Pareto-optimum compromises by software agents are also outlined in this chapter.

AGENT MODELLING

Contemporary informatics tools are not only expected to react properly to information processing commands, but also support managers in a more and more "intelligent" way, actively participating in attending their needs and adapting to their requirements. Agent-based systems, which appeared on the ground of Distributed Artificial Intelligence, are expected to fulfill these requirements.

Beside their direct application – for example in information management or distributed systems, these systems are often used as tools for modelling real world events. Despite some drawbacks indicated by the critics of the agent-based attitude to modelling, this approach has a number of advantages (Paprzycki, 2003), especially when complex issues are being modelled – business negotiations being undoubtedly one of them.

Models based on the Agent-based Systems are computer programs, which attempt to simulate various occurrences by means of virtual "agents" representing business system elements. The approach to programming may be completely different – ranging from using known in expert systems analysis (if-then), to learning algorithms (neural networks), which enable agents to learn and modify their behavior during simulation. These models may be based on historical data and it is possible then to create a situation in which model exactly renders the behavior of a real system.

Autonomy is considered to be the most important feature of a software agent, taking into account additional condition determining the way of knowledge representation. On this assumption, software agent is defined as a computer program, in which:

- Knowledge of the problem domain being program operation range, used by program when finding the solution to the set problem is gathered in knowledge base and represented by means of knowledge representation method in artificial intelligence (for example rules, scripts, logic, etc).
- Program has exclusive rights to read and modify its own knowledge base.
- Program makes decisions exclusively on the basis of the knowledge contained in its own knowledge base and in accordance with its own state of calculations.
- Program is equipped with symbolic communication language enabling it to inform the environment about the state of its own knowledge base (for example to send communicates to other autonomous agent programs concerning performed operations).

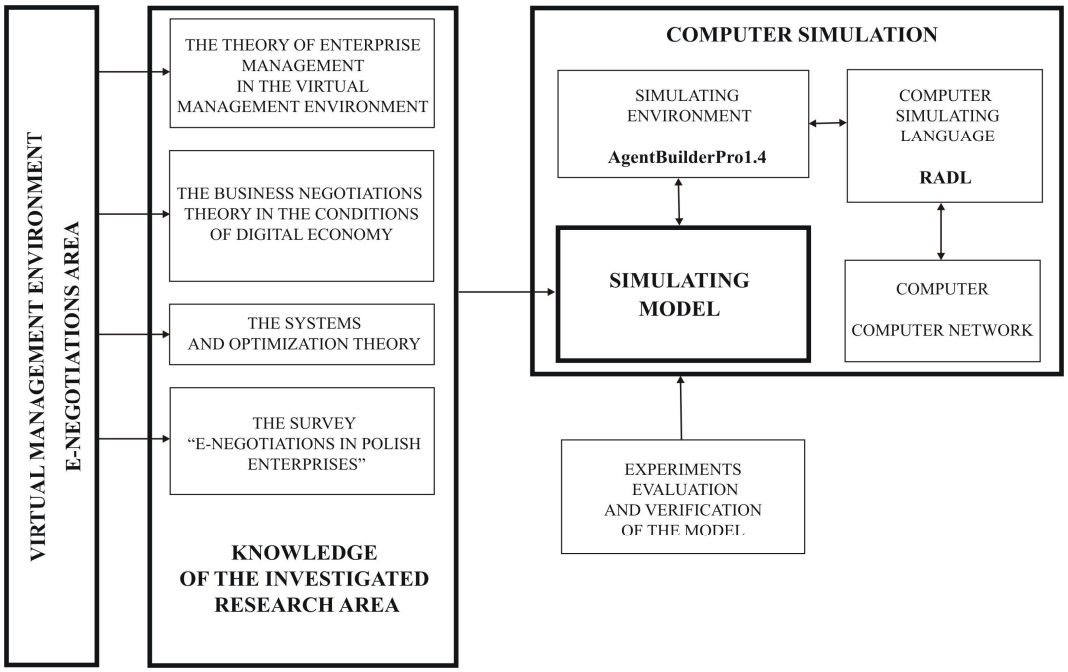
Thanks to software agents – constituting even a higher level of programming abstraction than functions or objects – it is possible to overcome the complexity of the modelled problem through dividing it the into smaller sub-problems. Each agent can be programmed in such a way, that it becomes an expert in solving one task.

COMPUTER SIMULATION METHODOLOGY IN NEGOTIATION PROCESSES RESEARCH

The study of business negotiation processes requires application of active, experimental research methods – computer simulation being one of them. This is an interdisciplinary research method, thus applying this method in negotiation process research requires applying achievements of different schools and scientific specialties. Accessible knowledge concerning researched negotiation processes should be used during construction of the simulation model. It must be selected on the basis of the theory of enterprise management in the virtual management environment, the business negotiations theory in the conditions of digital economy, the system theory, the optimization theory, and on the basis of the survey "E-negotiations in Polish enterprises" – Figure 1. The system theory provides principles for construction of the model structure. The optimization theory supports the model analysis and verification. The computer simulation method requires cooperation of the following elements: the simulating model, the computer, the computer network, the computer simulating language and the simulating environment. *AgentBuilderPro1.4®* software of *Acronymics, Inc*, was chosen to constitute the simulating environment (Kiełtyka and Niedbał, 2005).

Development of electronic communication influences the change of traditional, interpersonal forms of negotiating and concluding contracts. Organizational structure of enterprises is subject to change as well. More and more often it is distributed and susceptible to cooperation with other transactors. Network and virtual organizations are being created. A network organization is defined as "*a set of more than two autonomous organizations, bound with cooperating ties*", where the features of these bonds are presented. "*The forms of cooperating operations between the cooperating sides are negotiations and agreements not competition*" (Perechuda, 2000) – is one of these features. Thus, negotiations between enterprises operating within a network organization are of an integrative character. A virtual organization, on the other hand, is defined as "*a temporary network of autonomous enterprises (suppliers, customers, even former competitors) linked by means of information technology in order to share knowledge and access costs to new markets*" (Perechuda, 2000). In this

case negotiations are also of an integrative character. Due to such a kind of negotiations there is a possibility of creating synergy effect, characteristic of the virtual organization.



Where: RADL – Reticular Agent Definition Language

Figure 1. Methodological system of computer simulation in negotiating processes research
Source: own analysis

Negotiations of an integrative character are investigated in the present paper and presented in Figure 1 methodological system concerns negotiation process research of this character.

GENERAL ASSUMPTIONS OF THE SIMULATION MODEL CONSTRUCTION

The analysis of the conducted by the authors survey and interviews (Niedbał, 2005) justifies the need of elaborating an application aiding managers in conducting negotiations, especially in Business-to-Business relations. The above-mentioned survey and interviews with the representatives of management were conducted in 172 Polish enterprises of Silesia region, operating mainly on the basis of traditional-internet business model. According to the survey respondents the two stages of business negotiations are of particular interest and there is a possibility of their partial automation:

- Gathering, analyzing and making market information available to managers (research in this area is being conducted by the authors within the 1H02D0727 research project "Multiagent systems and information flow integrators application in market information management").
- Negotiating transaction conditions – exchange of offers, their evaluation and working out initial compromise (research area investigated in the present paper).

Having accepted the agent approach to negotiation process modelling, computer programs – software agents (Niedbał, 2006) can negotiate on behalf of managers. The proposed group of software agents that require the manager to be present during negotiations consists of the three basic kinds of agents – Figure 2:

- The Manager Interface Agent – its task is to facilitate human interaction with the system and present the results of work in an intelligible form.
- The Task Agent – it analyses the tasks introduced by man and divides them into elementary tasks.
- The Negotiating Agent – it performs elementary tasks the Task Agent assigns to it.

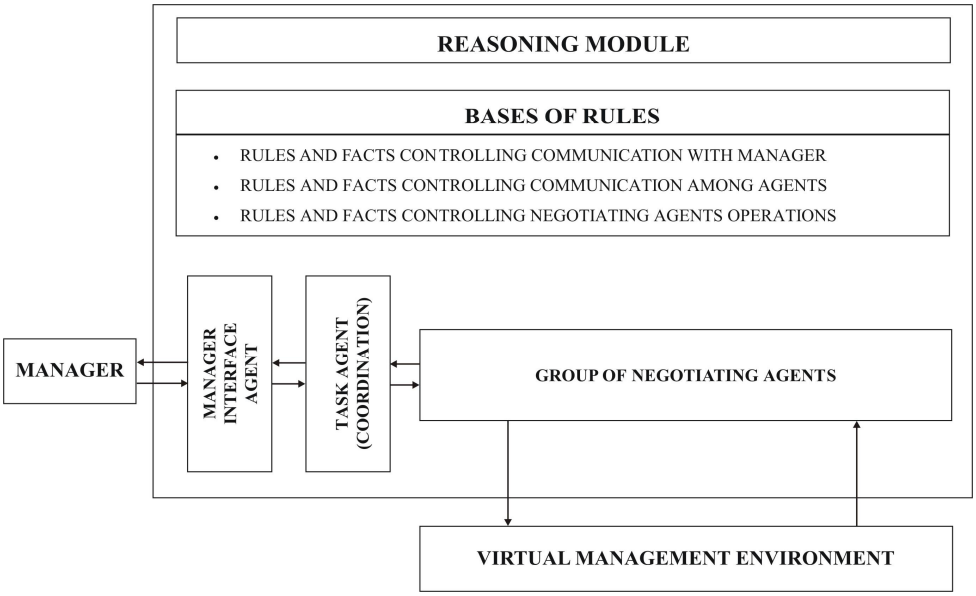


Figure 2. General architecture of the group of agents aiding managers in negotiations
Source: own analysis

The research concerning construction of the simulation model was divided into the following stages:

- Problem domain analysis.
- Defining ontology of electronic negotiation process.
- Determining model architecture – formulating, describing and assigning tasks to software agents.
- Establishing rules for software agents.
- Determining negotiation protocol.
- Simulating research of the proposed model for optimization in Pareto sense.
- Evaluation and verification of the proposed model.

Presented in Figure 2 the Negotiating Agents take over the tasks of exchanging offers – so called packages. The offers, that is lists of points to agree on and their weights, are sent as command content of KQML (Knowledge Query and Manipulation Language) language. This takes place using the negotiation strategy determined in the protocol. Because of this, it is possible to incorporate within the KQML information content messages understandable for the negotiating sides. It was assumed then, that software agents share common ontology. The points to agree on are, among others: price, quantity, delivery conditions and punctuality, terms of payment, guarantee terms, discounts. The packages are evaluated and worked out by the Negotiating Agents possible compromises are presented to managers to accept, or modify, in respect of the weights of particular points to agree on. If the agreement is accepted, the Negotiating Agents cease their operation, and man takes over the final stage of negotiations concerning signing the agreement and settlement. However, in case of lack of acceptation, the Negotiating Agents work out compromise again or their operation is interrupted.

The criteria for negotiated packages evaluation is the value of their usefulness, defined by the formula (1) (Kersten and Noronha, 1998):

$$\sum_{i=1}^{m}\sum_{j=1}^{n_i} u_{ij} x_{ijk} = U(p_k), \quad (1)$$

where:

$U(p_k)$ – p_k package usefulness,
k – number of packages,
i – i point to agree on,

j – j option for i point to agree on,
u_{ij} – partial usefulness of j option for i point to agree on,
x_{ijk} – binary variable indicating if j option of i point is present in p_k package,
m – number of points to agree on,
n_i (i=1……m) – number of vital points to agree on.

It may happen that the reached p_k compromise is inefficient – this means that among the packages there may be found at least one p^* package, for which its usefulness for the negotiating sides is fulfilled by the presented below inequalities (one of them has to be a strict inequality) (2):

$$U_a(p^*) \geq U_a(p_k) \text{ and } U_b(p^*) \geq U_b(p_k), \quad (2)$$

where: a - identifies the first negotiator, and b - the second one; p^* package is a rationalization of p_k compromise in Pareto sense.

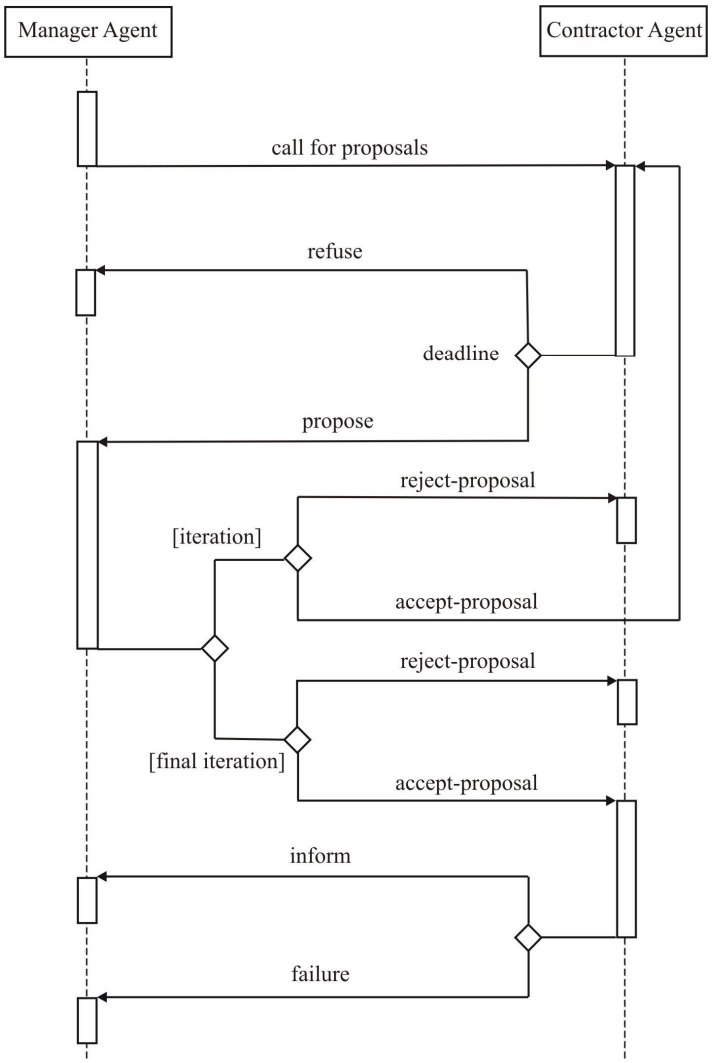


Figure 3. Iterated Contract Net Protocol – sequence diagram in UML language
Source: (Niedbał, 2006)

The Iterated Contract Net Protocol was accepted as the mechanism of information exchange among software agents – representing managers in reference to exchange of offers and generating Pareto-optimum compromises. This is a mechanism

based on the principles that regulate the real market of tenders and cooperation offers. The communication among software agents is realized through exchange of the messages demanding and delivering offers and the evaluation of the delivered offers by the manager. The dynamic sequence diagram describing functioning of the Iterated Contract Net Protocol is presented in UML language, in Figure 3. It illustrates the sequence of information sending in time.

The "manager agent" starts the exchange of information by sending its proposed offer to the "contractor agents". In response it receives counteroffers or resignation from further negotiations. When the maximum time of waiting for response elapses, the "manager agent" analyses received counteroffers, choosing the ones it wants for further negotiations. It sends its acceptance signifying the will of further negotiating the suitable "contractor agents", while the rest of them receive so-called proposal rejection information. After a specified number of iterations, in response to the initial agreement the "contractor agent" sends the "manager agent" information about the status – acceptance of the reached compromise or possibility of error occurence.

CONCLUSION

The aim of the research, which general characteristics is presented in this paper, is to elaborate the negotiation process model in the virtual environment of enterprise management. It will allow to continue the work on creating a computer system aiding electronic negotiations, based on agent system.

The results of the conducted survey show that negotiations are an important element of contemporary enterprise management (Niedbał, 2006). According to the respondents business negotiations are conducted regularly in the enterprises and their role is going to increase. Quite often they are complex- multilateral negotiations.

We plan to elaborate a prototype system for the production-trade network organization operating in the metallurgic industry in the Silesia region.

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REFERENCES

1. Kersten, G., Kersten, M. and Noronha, S. (1998) Computer assistance and negotiation processes study, *Zagadnienia Naukoznawstwa*, Vol. 136, No. 2, 202-227.
2. Kiełtyka, L. and Niedbał, R. (2005) A Conception of Multiagent Management System of Dispersed Market Information – E-negotiations Area, in Cordeiro J., Filipe J. (Eds.) *Proceedings of the 2nd International Workshop on Computer Supported Activity Coordination CSAC 2005*, Miami, USA.
3. Niedbał, R. (2005) Multiagent system as an e-negotiations aiding tool, in Kiełtyka L. (Eds.) *Multimedia in business and education. Knowledge management in education, multimedia information technologies*, *Volume II*, Białystok, Fundacja Współczesne Zarządzanie.
4. Niedbał, R. (2006) Agent paradigm of building electronic negotiations aiding system, in Kiełtyka L. and Nazarko J. (Eds.) *Methods and processes improving enterprise management. Chosen issues.* Warszawa, Wydawnictwo Menedżerskie PTM.
5. Paprzycki, M. (2003) Software agents as software development methodology, in Z. Huzar and Z. Mazur (Eds.) *Problemy i metody Inżynierii Oprogramowania*, Warszawa, WNT.
6. Perechuda, K. (2000) Future enterprise management. Conceptions, models, methods, Agencja Wydawnicza Placet, Warszawa.