

# AN INVESTIGATION INTO AGENCY REQUIREMENTS IN E-BUSINESS INFORMATION SYSTEMS

## *Position paper*

Pascal van Eck, Roel Wieringa

*Department of Computer Science, University of Twente, P.O. Box 217, 7500 AE Enschede, The Netherlands*

*Email: vaneck@cs.utwente.nl, roelw@cs.utwente.nl*

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Abstract: In digital marketplaces, companies are present in the form of their software, which engages in business interactions with other companies. Each organisation that is active in the marketplace is trying to reach its own business goals, which may be in conflict with the goals of other organisations. The software by which an organisation is present in a digital marketplace must act on behalf of this organisation to reach these goals. Thus, there is a relation of agency between the software and the organisation that the software represents. This relation gives rise to a number of agency requirements on the software, which are identified and compared with functional requirements. Results in the area of Multi-Agent Systems may be applicable in the design of information systems for which agency requirements hold. A number of such results are briefly described, and further research issues are identified.

## 1. INTRODUCTION

The omnipresence of the Internet has enabled companies and other organisations to do business in digital marketplaces. In such marketplaces, companies are present in the form of their software, which engages in business interactions with other companies. Like a traditional marketplace, a digital marketplace is a competitive environment. Each organisation that is active in the marketplace is trying to reach its own business goals, which may be in conflict with the goals of other organisations. The software by which organisations are present in a digital marketplace must in some sense implement these goals: they must act to reach these goals. If we add to this the requirement that businesses want to engage in *flexible* cooperations over digital networks, we are led to requirements of *agency* for the software that represents businesses. This position paper provides an elaboration of this argument.

The structure of this paper is as follows. First, Section 2 discusses agency and presents a number of agency requirements for e-business information systems. We also contrast the agency requirements with functional requirements on e-business information systems. The ultimate goal of our work is to

develop a systematic design method for e-business information systems. In Section 3, we describe some theories and technologies from the area of multi-agent systems that may be of help to reach this goal. After that, we identify a number of research issues that appear in the development of such a method.

## 2. THE REQUIREMENT OF AGENCY

The notion of agency is well-known in philosophy and the social sciences. In law, agency is the relationship between two legal bodies where one legal body, the agent, acts on behalf of the other (the principal), and represents the other legal body towards third parties. In e-business, there is a similar relation between organisations and their information systems that represent them at a digital marketplace: these information systems act “on behalf of” the organisations that deploy them.

In traditional (non-digital) business relations, agency relations occur frequently, in the form of e.g. brokerage, commissionaires, and sales representatives. These agents are autonomous actors in an economic or legal sense, whose actions are motivated by self-interest. Human agents autonomously choose to engage in agency relations with principals, pre-

sumably because doing so promotes, or does not conflict with, their own interests. One could argue that the notion of agency is not applicable to information systems, i.e., to software, because information systems that represent an organisation at a digital market are owned and deployed by that organisation, and are fundamentally deterministic and not autonomous. For two reasons, we think that it is nevertheless beneficial to view agency as a requirement for e-business information systems:

- The ultimate goal of organisations in a digital marketplace is to do business digitally, i.e., to engage in transactions that are valuable for all parties. Organisations deploy information systems (software) to reach this goal. A fundamental assumption with respect to the environment of these information systems is that this environment is *competitive*: each organisation aims at maximising the profit of its transactions, often at the expense of the profit of other organisations<sup>1</sup>. This assumption is unique for e-business information systems. In other application areas, the environment is (implicitly) assumed to be cooperative: there is an (implicit) ultimate goal that all information systems in the environment act to satisfy, and these information systems act benevolently to reach this goal. By engaging in an agency relation, a human agent is bound to moral and legal rights that protect the interest of the principal. In the competitive environment in which e-business information systems operate, an organisation that deploys these information systems needs similar protection: its software should act solely to promote the goals of the organisation. In other words, the organisation needs an agency relation with its information systems.
- The use of well-known notions from other areas than Computer Science enables application of techniques (e.g., game theory, and law) from these areas to e-business information systems. For instance, if information systems can be proved (in a legal sense) to comply with agency requirements, existing or slightly modified laws of agency are applicable.

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<sup>1</sup> Cooperation frequently occurs in competitive environments, either as a compromise to reach goals that are otherwise unreachable, or because subgoals of different organisations are not in conflict and benefit from synergy.

## 2.1. Agency and agency requirements

As stated above, information systems that represent an organisation in a digital marketplace should in some sense be “bound” to obligations that are similar to the obligations in agency relations between legal bodies. These information systems are artefacts, selected or constructed by or on behalf of the organisation, not people nor legal bodies, and so the obligations to which they are “bound” are simply part of the requirements that these artefacts must satisfy. Therefore, the obligations to which these information systems should be “bound” can be stated as requirements on their behaviour.

In our opinion, the following four requirements on the behaviour of an information system ensures that the interests of an organisation that has itself represented by this information system, are protected. The requirements are listed in increasing order of complexity.

- Goal-directed reactivity: the information system should be able to react to events in its environment such that the reaction promotes the goals of the represented organisation.
- Planning and re-planning: the information system should devise plans to help the represented organisation to reach its goals, execute these plans, monitor the execution and re-plan if necessary.
- Subgoal-setting: the information system should, within the charter defined by its overall goal, decompose the goals of the represented organisation into subgoals, for which subsequently plans are devised, and re-planning is performed if necessary.
- Learning/adaptive behaviour: the information system should learn from previous experiences to react, plan and set sub-goals more efficiently in the future.

We expect human and artificial legal agents to behave this way when representing a principal, and so we require software agents to behave in a similar way. Together, the four requirements presented above constitute the agency requirements on the behaviour of an information system. Most probably, the requirements can be further decomposed to form a deeper hierarchy of agency requirements.

**Table 1:** Agency requirements and functional requirements for service composition.

	Goal-directed reactivity	Planning & re-planning	Subgoal-setting	Learning/adaptivity
Sourcing	X	X	-	X
Brokerage	-	-	-	-
Supply chain management	-	-	-	-
Selection/negotiation	X	X	X	X
Contracting	X	-	X	-
Collaborative work	-	-	-	-

## 2.2. Relationship with e-business functional requirements

The hierarchy of agency requirements presented in the previous section constitutes one dimension of requirements for e-business information systems. Another dimension can be distinguished, which consists of a hierarchy of required system functions. (Non-functional, or quality, requirements such as ease of use, scalability, robustness, and ease of maintenance can be distinguished as a third dimension.) The Electronic Commerce Domain Task Force (ECDTF) of the OMG presents a number of general e-business functions (ECDTF, 1997), from which the following list is derived:

- Sourcing: finding suppliers of goods and services, finding matches between business parties.
- Brokerage: matching business parties.
- Supply chain management: maintaining relations with suppliers to ensure availability of resources in the future, managing sales channels to ensure possibilities for sale in the future.
- Selection/negotiation: selecting suppliers based on the results of sourcing and brokerage and settling of incompatibilities between goals of suppliers and own goals.
- Contracting: management of the process of making the results of selection and negotiation explicit.

- Collaborative work: contrary to goods, the value of services is created in the delivery process of the service to the customer.

The ECDTF distinguishes additional functions, such as payment and cataloguing, and uses different characterisations of the functions. Specific e-business information systems provide one or more of the functions presented above. For each of these functions, one or more of the agency requirements may apply. As an example, consider matchmakers in e-business. Agents that match services in e-commerce applications collect information on supply and demand of these services. As a result, matchmakers have the opportunity to create added value by composing services for which no supply but ample demand exists, acting as the supplier of the composed service. A requirements analysis for an information system that autonomously manages service composition may result in the requirements as presented in Table 1.

Table 1 indicates that brokerage, supply chain management and collaborative work functions are not required at all. Sourcing, selection and negotiation, and contracting functions are required with various agency requirements. Thus, the agency requirements can be used as a searchlight to identify relevant requirements for e-business information systems.

## 3. DISCUSSION

Our ultimate goal is to develop a design method for e-business information systems, for which the agency requirements in the previous section apply. In Section 3.1, we briefly discuss some results from multi-agent systems research that may be valuable. In Section 3.2, we identify further research issues.

### 3.1. Technologies and results from multi-agent systems research

In the field of multi-agent systems (MAS) research, software systems are analysed and designed as if they consist of autonomous, rational actors called agents. The notion of an agent in MAS research does not necessarily refer to the *relation* of agency as presented in Section 2. However, as MAS research focuses on rational behaviour of self-interested actors, we expect that results from this research are applicable and valuable for the analysis of agency requirements for e-business systems. Results in this area are often characterised as relating to either agent theories, agent architecture, or agent languages (Wooldridge & Jennings, 1995).

- Agent theories. Many theories on rationality of individual agents and on relations between rational agents have been developed, too many to survey here. Of particular importance for agency requirements in e-business are various theories on deontic aspects of agents, and applications of game theory. Game theory is used in multi-agent systems research to design markets and to determine negotiation strategies for individual agents. A survey of approaches to automated negotiation (one of the functional requirements mentioned in Section 2.2) is presented in (Jennings, Faratin, Lomuscio, Parsons, Sierra & Wooldridge, 2001).
- Agent architectures. Many software architectures for agents have been proposed. These architectures describe how, in an operational sense, an agent rationally manages its goals in relation with a dynamic environment and the actions of other agents. A well-known and promising architecture is known as the BDI architecture (Rao & Georgeff, 1992). Several software frameworks exist that implement this architecture. We think that these frameworks are a good starting point for the design of e-business information systems for which the agency requirements apply.
- Agent (programming) languages. The most relevant results in this area are concerned with design methods for (multi-)agent systems. There has been a constant, but quite limited, development of such methods. At least two methodologies are adaptations of the well-known CommonKADS methodology for knowledge-based systems: MAS-CommonKADS (Iglesias, Garijo, Gon-

zález & Velasco, 1998) and CoMoMAS (Glaser, 1997). DESIRE (Brazier, Dunin-Keplicz, Jennings & Treur, 1997) is based on a two-dimensional view on agents: the hierarchical composition of reasoning components that realise the tasks of an agent, and the hierarchical composition of knowledge structures. A recent methodology is Gaia (Wooldridge, Jennings & Kinny, 2000).

### 3.2. Research issues

The notion of agency, its decomposition into agency requirements, and the relation with functional requirements give rise to a number of research issues that are not addressed adequately by results from the field of MAS research:

- Interplay between requirements. In general, different functional requirements of an e-business information system relate to different subgoals of the overall goal of the information system. If these subgoals are pursued concurrently, at times conflicts may arise. In this case, goal-directed behaviour associated with one function interferes with goal-directed behaviour of another function. It is not clear how such interference has to be managed.
- Bounded rationality. Purely goal-directed behaviour is often not possible, as it may require unlimited resources to compute which behaviour pursues a goal in an optimal way. Consequently, an agent is only able to act in a goal-directed way within the limits of its resources. This may lead to the identification of additional agency requirements to manage the expectations of the organisation that deploys the information system.
- Policies. In an agency relation, the agent adopts the goals of its principal and acts to pursue these goals on the behalf of the principal. Goals are statements of desired states that the principal tries to reach. Often, the principal is committed to policies, which are constraints on the possible behaviour that leads to the desired state. The question is how such policies can be incorporated in requirements analysis and design.
- Risk attitude. Goal-directed behaviour may confront an agent with choices between actions that reach a goal very efficiently, but with a high potential of failure, and actions

that are less efficient, but more safe. It is not clear how requirements analysis should capture the required risk attitude of an agent in relation with functional requirements and other agency requirements.

- Legal aspects of agency. The study of the legal aspects of e-business is only just beginning (Conan *et al.*, 2000). Various (national) laws of agency identify different types of agents. It is not clear if these types can be mapped onto the two dimensions of requirements presented in the previous section.
- Design methods. The design methods known from the field of multi-agent systems currently address competitive domains to a very limited extent. A design method has to be developed that integrates insights from the fields of cooperative information systems, multi-agent systems, economics, and legal aspects of e-business.

## REFERENCES

- Brazier, F. M. T., Dunin-Keplicz, B. M., Jennings, N. R., and Treur, J., 1997, 'DESIRE: Modelling multi-agent systems in a compositional formal framework', *International Journal of Cooperative Information Systems*, Special Issue on Formal Methods in Cooperative Information Systems: Multiagent Systems, M. Huhns and M. Singh, editors, 6(1):67-94.
- Conan, V., Foss, M., Lenda, P., Louveaux, S. and Salaun, A., 2000, 'Legal issues for personalised advertising on internet: The AIMedia case study', in Moukas, A., Sierra, C. and Ygge, F., editors, *Agent Mediated Electronic Commerce II*, volume 1788 of Lecture Notes in Artificial Intelligence, pages 40-67. Berlin: Springer-Verlag.
- ECDF, 1997, *The OMG/CommerceNet Joint Electronic Commerce Whitepaper*. <http://www.osm.net/upload/97-06-09.pdf>. Visited March, 2001.
- Glaser, N., 1997, 'The CoMoMAS approach: From conceptual models to executable code', in Boman, M. and Velde, W. van der, editors, *Multi-Agent Rationality, Proceedings of the Eight European Workshop on Modelling Autonomous Agents in a Multi-Agent World, MAAMAW'97*, volume 1237 of Lecture Notes in Artificial Intelligence. Berlin: Springer-Verlag.
- Iglesias, C. A., Garijo, M., González, J. C., and Velasco, J. R., 1998, 'Analysis and design of multiagent systems using MAS-CommonKADS', in Singh, M. P., Rao, A. S., and Wooldridge, M. J., editors, *Intelligent Agents IV. Agent Theories, Architectures, and Languages*, number 1365 in Lecture Notes in Artificial Intelligence. Berlin: Springer-Verlag.
- Jennings, N. R., Faratin, P., Lomuscio, A. R., Parsons, S., Sierra, C., and Wooldridge, M., 2001, 'Automated negotiation: Prospects, methods and challenges', *Journal of Group Decision and Negotiation*, 10.
- Rao, A. S. and Georgeff, M. P., 1992, 'An abstract architecture for rational agents', in Rich, C., Swartout, W., and Nebel, B., editors, *Proceedings of the Third Conference on Knowledge Representation and Reasoning, KR'92*, pages 439-449, San Mateo: Morgan Kaufmann.
- Wooldridge, M. J. and Jennings, N. R., 1995, 'Intelligent agents: Theory and practice', *The Knowledge Engineering Review*, 10(2):115-152.
- Wooldridge, M., Jennings, N. R., and Kinny, D., 2000. The Gaia methodology for agent-oriented analysis and design. *Journal of Autonomous Agents and Multi-Agent Systems*, 3(3):285-312.