

# The outcomes of the research in areas of application and impact of software agents societies to organizations so far. Examples of implementation in Polish companies.

Mariusz Żytniewski, Andrzej Soltysik, Radosław Kowal  
University of Economics in Katowice ul. 1 Maja 50 , 40-287 Katowice, Poland  
Email: {zyto, soltys, radek}ue.katowice.pl

**Abstract**—The development of information management systems stimulates the search for new forms of supporting business processes which take place in the organization. One of the solutions that can be applied here is software agents that enable support activities to the employee and the customer promoting information and knowledge about the organization. Such solutions are commercially available for several years in the form of interface agents, but there is insufficient research on the modeling, the applications and the impact on the organization and its environment. The purpose of this paper is to present theoretical research in this area regarding companies providing such solutions on Polish territory.

## I. INTRODUCTION

THE development of information management systems stimulates the search for new forms of supporting business processes. In addition to the systems aimed at processing and distribution of data and information, organizations are increasingly looking for solutions that support the processing of the knowledge held by their staff and its environment.

Recent research in this area indicates that such solutions should be built in the current concept of WEB 3.0, based on methods of semantic knowledge representation [10] and support the various stages of the business process. One of such solutions may be software agents. Knowledge driven multi-agent systems are one of the current trends in the development of software agent technologies [1].

The primary goal of this scientific research is the creation of new trends in the development of the concept of society of software agents in terms of ubiquitous communication for the purpose of supporting and improving business processes in knowledge-based organizations involving semantic solutions.

Such solutions can support the process of disseminating information and knowledge about the organization, contributing to the improvement of processes occurring in them by improving customer satisfaction and affecting him, not only during the implementation of the business process such as sales, but can strengthen ties with customers by presenting information and transferring intra-organizational knowledge also not related to the process. These solutions, built on elements of artificial intelligence, need to equip them with

adequately prepared and codified knowledge, which allows the user to communicate with the system.

The structure of the knowledge of the system and its features goes beyond the existing expert systems and other information systems which means that, in the case of its construction, it is necessary to search for new methods of their modeling and implementation.

One aspect of the research conducted by the authors was to demonstrate the approach of Polish companies regarding the construction of such solutions. For this purpose, a series of interviews with organizations based on the knowledge, that are dealing with programming agents during performing their everyday operations, had been conducted. This study consists of a diagnosis of key areas of application software agents in knowledge-based organizations. As an introduction to this research, organizations were divided into two groups: manufacturers or distributors and users of the software. At the same time the assumption was made that the manufacturers may also be the users, using this type of solution in the course of their business. The first stage of the qualitative research was the analysis of areas in which organizations creating or distributing this type of solutions support business processes and the problems faced by such organizations in the process of doing so. At the moment, we have conducted structured interviews with five larger manufacturers of this type of solutions in Poland. Some companies did not agree for an interview.

Interviews with representatives of those organizations were supposed to help in answering the following questions:

- To what extent software agents society can find its application in knowledge-based organizations?
- In what areas software agents society can support the business processes?
- What factors influence the limited applicability of the concept of software agents society?
- How is it possible to use intra-organizational knowledge in the process of achieving the objectives of software agents society?
- How to augment the organization's knowledge resources with the participation of agent technologies?

In the first part of the article the basic typologies of agent systems will be shown in the context of their intra-organizational use. The second part will present partial results of research on the issue of modeling agent solutions in the context of companies implementing such software in organizations that observe the need for computer support for the process of identification, codification, distribution and dissemination of knowledge in the area of business process execution.

## II. AGENT TECHNOLOGIES IN ORGANIZATIONS

Due to the characteristics of agents, i.e. autonomy, ability to recognize the context, pro activity and reactivity, and the ability to communicate and interact, the agents are mainly used in tasks that require distributed processing and exchange of information. The most frequently mentioned examples of agent-based approaches may include supporting the circulation of electronic documents, distributed problem solving, e-business and the use of agents on the Internet. However, they are not sufficient, as shown by the current study conducted by the authors, regarding application of software agents in knowledge-based organizations [6].

It is difficult to discern a consensus about definitions and a similar position among researchers and authors of various works. In terms of the life cycle of knowledge management systems, the approach presented here refers to the stage of dissemination and promotion of intra-organizational knowledge. One of the most interesting classification of agent systems applications are shown by Paprzycki in his work [5]. Referring to the use of software agents, he proposes the division of a sphere of existing applications of agents into three classes.

The first group includes the use of agents playing a role of components of distributed systems, in particular, those which are associated with Internet use. In this group, one can specify searching agents which mission is to find a well-defined information based on a specific sequence of keywords, or on the basis of questions posed in natural language.

The second group of agents mentioned in this scheme is used as a tool for modeling complex systems. Agents are seen as mechanisms that allow for mapping and modeling of real world phenomena. In particular, in this group business process modeling should be distinguished.

The third group are agents used to manage and personalize information supporting the user by means of, for example, animated characters. Now, thanks to continuous development of IT tools using this kind of technology becoming increasingly common, especially in systems using sites or web portals, which have become the natural environment of operation for interface agents or chatter bots. Agents are often inspired by their living counterparts. The animation uses movie clips and images of people who become a prototype of the agent. This type of user agents support services such as banking, corporate web pages, and wide range of online shops. Typically, they are built on the basis of aiml language i.e. [7].

This type of agent-based solutions can be divided into the following groups [2]:

Purchase agents (shopping agents) represent particular interests of customers by searching for the best offer for the customer and facilitating the process of making a purchase in the online store. Agents in this role shall make, on the client's behalf, a selection of a commercial information available via the Internet. Often it is possible to use them to formulate orders and finalization of commercial transaction without direct user intervention.

Selling agents represent the interests of the sellers and are used to streamline the sales process. Frequently such agents are supported by animated characters which role is to ensure the communication with customers in a natural language or close to natural. Agents participate in the whole business transaction, or in some stages. It is possible to conduct negotiations between purchase agents and selling agents. Selling agents have the ability to tailor their offerings to the needs posed by potential customers – the diagnosis takes place through dialogue with the customer, or personalized user profiles.

Marketing agents gather, through dialogue or searching the web, all available customer information and analyze it using statistical and econometric methods to optimize and allow preparing marketing campaigns targeting specific customers. Also they are used to adjust a supply to the strategy and the expectations of the market.

Virtual assistants support the user in the search for a specific item, or while visiting a particular site. Agents of this type can: represent the company by answering questions asked by clients, give visitors advise about how to navigate through the website, or help with the choice of a particular product. Agents have mechanisms which help them in searching for information/messages useful for the customer. Assistants support the promotion of new products as well. Software agents should support natural language processing and generate explanations for customers [8].

Specified typologies, related to the perception of agents in the context of the solutions that are part of information systems, can be extended on the basis of the research on agent-based support for knowledge-based organizations and are the easiest type of solutions in the context of building software agents society [10].

The classifications discussed here are related to modeling software agents and indicate that we should consider them in terms of solutions supporting and perfecting processes within the organization. These solutions allow the distribution of codified intra-organizational knowledge in the course of and besides the implemented business processes. They are able to become not only a part of the information system, but also a knowledge management system.

As indicated by L. Dignum and V. Abecker [4], from the point of view of the organization, there is an inherent dichotomy between the goals of the business processes and the objectives of knowledge management processes – employees always try in the first place to achieve business goals,

because they are to be held accountable for its execution. Taking care of organizational knowledge, or adding to the common pool of knowledge, its organization or even browsing is perceived as the goal of much less importance than effective performance of business-related tasks. Therefore, for effective implementation of knowledge management it is necessary to emphasize its importance for achieving the business objectives of the organization.

Knowledge management addresses issues that change over time – all of the elements of an organization, affecting the knowledge management system, is a subject to change [4]. Therefore, it is difficult to design and implement a system that is at the same time generic, equally useful for all departments and members of the organization and will be evolving without losing its usefulness. Another disadvantage is the fact that very rare knowledge management system is being implemented at one time across the whole organization – in majority of cases an incremental approach is used, when system is at first implemented within a single department, and then made available to the others.

Taking into account these assumptions about requirements and challenges for the design of modern knowledge management systems it must be noted that such systems should have a built-in ability to adapt to a changing environment. At the same time, these changes can affect both IT infrastructure – especially considering the trends associated with the growing use of mobile devices for accessing the shared resources of knowledge, as well as the changing needs of users whose demand for knowledge continues to grow along with the participation of knowledge in the creation of value added. This trend, involving the use of mobile devices also affects a second important aspect related to the design of modern knowledge management systems. It is the growing importance of the social nature of knowledge which in recent years has been becoming increasingly important, mainly due to the prevalence of social media [3].

Considering the increasing demand for the interaction between humans results in an increased interest on the role of information systems, including knowledge management systems, in building relationships. On the other hand, global competition and the increasing rate of information processing necessitates the development efforts related to the enrichment of knowledge management systems by adding user context, what is supposed to result in their personalization – see the above-mentioned demand for knowledge management systems adaptation to the specific needs of users, related to their organizational roles. Always present is also a need for systems that will not only provide adequate information, to the right people at the right time, but also will work proactively towards enhancing audience's creativity. The development trends of ubiquitous processing and geolocation indicate the need for the study on the integration of knowledge management systems into the human's environment, so that they become an integral and, from the point of view of the user, invisible part.

As pointed out, an interesting and increasingly wide spreading use of software agents is supporting activities related to the overall communication with the customer. Software agents, in the form of virtual advisors, appear on the websites of companies, taking on the role of a seller who is able to enter into dialogue with the customer, assess and identify customer needs and propose the solution in form of a particular product. Of course, the virtual advisor is also able to properly advertise the product. Similarly, though in a slightly different fragment of marketing communications, agents providing after-sales service work. Their job is to answer customer questions related either to the product or service and receiving complaints and / or propose a solution to the problem. As a result these solutions are used not only to provide knowledge regarding business processes during their execution, but they can help users who are looking for answers to questions that go beyond the core business of the organization. Thus, in terms of the construction of modern knowledge management systems, software agents can be a coherent part of such systems, supporting the different stages of its life cycle and actively supporting the knowledge-based organizations.

The issues related to the software agents usage indicate that modeling software agents society is not a trivial task and requires reference not only to the knowledge about the architecture of information systems, but also to the model of knowledge for such system. This knowledge model will not only serve as a knowledge structure for an agent, but will provide links to the knowledge embedded into other information systems of an organization, which is of great importance especially in the context of building heterogeneous software agents society [10].

### III. THE OUTCOMES OF THE RESEARCH SO FAR

The advancement in the concept of software agents society and a variety of approaches to its architecture and methods of construction, caused that the research has been focused on providing the theoretical framework for building the multiagent solutions that offer support for the organizations, in particular, knowledge-based organizations. Such agent societies support the processing and distribution of information and knowledge using the mechanisms of semantic knowledge representation and operate in context of ubiquitous communication. Four of the indicated assumptions limited our research to the application of agent-based solutions in supporting the human – computer interaction and in the context of their possible use as part of knowledge management systems.

As indicated earlier, these solutions can be considered in the context of interface agents, each with its own codified knowledge base, associated with the information systems of an organization and actively participating in the ongoing business processes. Analysis of commercially available solutions pointed out that the vast majority of applications of agents in organizations are "Virtual advisors". All surveyed organizations offer such solutions. Various solutions, how-

ever, differ from each other significantly. Most of the solutions with primary goal in the form of finding and providing information to users, use a limited set of questions, that they are able to recognize, so their functionality is very limited. As a mean to overcome this limitation some solutions use tips in the form of 'choose-from-list' mechanism. One of the analyzed solutions uses natural language analysis speech that is used in interpreting user's statements, coupled with the speech recognition and biometric methods, which makes the solution more user-friendly, efficient, and significantly expands the range of other possible applications and makes them more versatile. One of the producers also highlights the special feature of their solution, which is the ability to focus on the essence of a "conversation" and the ability to return and resume the interrupted thread. Another solution integrates seamlessly with the entire service platform designed for supporting the public sector. Among other features automatic handling of callers to the call center can be distinguished. This solution, as the only one, uses a greater number of agents at the same time. Despite the focus on the same topic, they don't cooperate, nor create a society. However, it is possible to examine the software agents acting individually.

#### *A. The benefits of using the software agents in an organization.*

Organizations using software agents take advantage of a wide variety of benefits, among which the most frequently mentioned is an improvement for internal and external communication channels. The main functionality of virtual advisors is to provide the end customer with instant access to information without having to call the hotline or search for a specific Web page. This is undoubtedly the improvement of the process of communication and provides new channels of communication for external users. Virtual advisor also facilitates the usage of internal applications for employees. It provides a kind of help desk, which is the first line of support, and eliminates the need for traditional help files. An employee who is not proficient in terms of the usage of the software may simply ask a question related to the functionality of the software, and agent gives him or her the expected answer. Given this it surely improves the internal communication and speeds up access to information and knowledge for internal stakeholders. The use of software agents in a call center to answer the most common customers' questions brings measurable benefits for the organization, by reducing the cost of its service and by increasing customer satisfaction.

#### *B. Software agents as a tool for perfecting business processes in the organization.*

With regard to perfecting business processes in the organization of various types of software agents are utilized in many different ways. The use of agents typically require clarification and formalization of the knowledge processing or even the introduction of knowledge management given the fact that the virtual advisor requires actual knowledge.

The most obvious seems to be looking for improvement in the distribution of knowledge, e.g. the provision of information, and the customer service process, especially in those organizations where existing procedures are the most formal and well documented.

Agent interface representing intelligent search mechanism, streamlines the process of handling an applicant in the office, which, due to its use, becomes more efficient and faster. Similarly, software agent can support internal users which execute formal, well-defined and well-described processes, by reducing the time and improving access to information necessary for the resolution of the problems. Thus consulting the agent will optimize the business processes.

Organizations recognize another opportunity to improve business processes in running the trainings via the Internet supported by software agent, what makes it possible to carry out an individual training program, which depends on the needs and expectations of participants. Despite the fact that the lecture is run by a machine the participant may, in the course of his or hers study, receive help in the form of answers to his or hers questions. According to a representative of one of the companies participating in the survey it is a significant improvement in the business process. Software agents are also reported to bring benefits in the case of supporting the process of taking orders in an online shop. The survey results include a description of sales service process improvement in which information software agents are used to replace the traditional communication channels like inquiries, E-mail, or instant messaging like Skype or MSN Messenger, in situations where it is necessary to identify and/or specify the technical parameters of equipment sold or to clarify some definitions. The customer can get the answer on-line from the agent. In addition to the obvious benefits of cost savings and speeding up the process, companies indicated a higher attractiveness of this form of assistance.

#### *C. Factors affecting the limited applicability of the concept of software agents society in the organization*

Organizations share the same view when it comes to the identification of key factors influencing the limited applicability of the concept of software agents society in the organization. Typically, respondents indicated three main factors.

As a main reason social factor was indicated, i.e. lack of awareness of the existence of such solutions and potential benefits of its application, or perceiving them as a toy, amusing marketing gadget on the site, and not the real support. Both organizations and consumers are not yet ready for the introduction of software agents. Usually it is related to a misunderstanding of its purpose, as stated above, and a fear that stems from believing that they are a tool for spying on the users. Users are also not convinced about the reasonableness of the use of such mechanisms. Agent systems producers count on the fact that the situation will change over time, what will result in enhancing the intelligence of these solutions, which will enable them to assertively respond to user's behavior and intelligently adapt to his way of thinking.

Manufacturers also point to the problems that affect the older part of the population which is related to using the keyboard to communicate with the agents. Vendors try to develop new interfaces that eliminate the issue of typing. Probably the most interesting thing happening nowadays, regarding that matter, is the introduction of speech recognition and touch screens that release older people from necessity of using a keyboard. With speech recognition fluent conversation with the agent will be possible, rather than using written text.

Important factors limiting the implementation of software agents are organizational problems. We identified several of such problems that are the most common organizational factors hindering the use of agent-based solutions:

- lack of preparation of the organization for the introduction of agent systems, arising from organizational culture,
- lack of appropriate procedures,
- lack of separated and unambiguous definitions of business processes.

Manufacturers assume that a wider promotional campaign carried out by both the companies offering these solutions, as well as institutions that procure them, would result in their wider adoption in the organizations.

Problems related to knowledge management in organizations which plan to implement software agents are also indicated. There are potential users, organizations that would gladly implement such solutions, which have the necessary budget, are aware of the interest of the customers, but they realize that they are unable to adequately manage the knowledge, deliver it on time or in the correct amount that could be used by a virtual adviser.

An important factor limiting the applicability of agent solutions are technical and technological conditions. We distinguish two groups of such conditions. The first one is the constraints in the network infrastructure, making it difficult to make service call. For example, "virtual advisors" are the solutions which depend heavily on the access to the Internet connections. In Poland, the network infrastructure is still not sufficiently developed, what makes it difficult for everyone to gain access to and communicate with the virtual consultant. Residents of highly urbanized areas, usually the big cities, do not have this problem, while those living in poor urban areas, country side and terrain such as mountains may experience difficulties in accessing the Internet, which may be one of the main technical barriers.

Although informational technology is a subject for constant development, despite the significant progress and enormous achievements in the field of artificial intelligence, from the point of view of the technology that is used, we still are not able to create solutions which "thinks" like a human being and is able to "come up with" something to talk about on its own. Agent may conclude faster and much "better" than a man, it can make use of an analytical knowledge it has accumulated, but it is not in a position to come up with

the subject of conversation. It can only base on pre-defined themes.

Most manufacturers indicate inadequacy or lack of mechanisms that would allow for a complete "mapping" features of the human brain that would allow for their repetition by the machine. Surely a computer, the machine, the computer program will neither act and "think" in a way the human being does, nor operate on the basis of associations. Most manufacturers also point to inadequacy or lack of tools for effective speech recognition, which, in their view, is blocking the applicability of the available solutions. Those that are currently available on the Polish market are still not mature enough and do not allow free communication and unambiguous speech recognition. Most of these tools allow to communicate in English, and users of agent systems, especially the virtual advisors, rely mostly on Polish, which is country's official language. It is possible, as shown by some manufacturers, to unblock the communication channel with use of software agents, which in turn should greatly improve their adaptation.

Another blocking factor, indicated by the respondents, is economic in its nature – namely agent solutions are not cheap. On the other hand the survey revealed that it is possible to overcome this one by applying for different types of subsidies that offer financing the implementation of such innovative solutions.

#### *D. Use of intra-organizational knowledge in the process of achieving the objectives of software agents.*

Key activities in the utilization of intra-organizational knowledge recognized by respondents comprise any action performed in order to collect and organize the knowledge base, for example creating a repository of knowledge, which can be used in the future. Filling the agent system with a domain knowledge requires the collection of this knowledge in different places and in different ways. Accumulated knowledge should be structured, but in different organizations, such structure will be achieved differently.

Agent systems vendors often report a lack of proper knowledge and preparation on the customer's side and difficulties in persuading the client to systematize the knowledge necessary for the functioning of the system.

Another vital activity appearing in customer service area, both internal and external, is the acquisition and distribution of knowledge, which should be strongly tailored to the individual needs of the user. As the survey shows it is always easier to implement such behavior in the case of a client who is aware of knowledge management and accumulation.

The organization aware of the needs of the knowledge management is more eager to collect the knowledge needed by the implemented solution. However, there are many organizations that lack the awareness of having such knowledge structured and stored. It is then necessary to establish close cooperation with persons designated and responsible for ordering and systematizing knowledge and implementation of specific procedures. This results in increased awareness of

the need for the process of collecting, organizing the knowledge and preparing appropriate procedures for structuring and organizing the knowledge within the organization.

#### *E. Agent technologies in enrichment of organizational knowledge*

Basically, the enrichment of organizational knowledge with the use of software agents is possible mainly by their usage in the acquisition of knowledge which is necessary to effectively carry out business processes of the organization. The agent system has to be taught. In the context of agent systems it means that agent have to be able to learn, i.e. gain knowledge from different organizational sources. There is also a body of knowledge outside of an organization which can be used by agents indirectly, for example through a solution of "browser of quotations" or through the integration with different types of external knowledge bases.

Agent-based solutions may be able to query different databases. Usually it is not a problem to teach agent the knowledge in a particular field. It can be done through connecting him to the existing knowledge base but to do so we need a help of a knowledge engineer.

The required knowledge can be sought out through a semantic search engine that collects information from various websites. Another way to supply resources of organizational knowledge may be communication with the user in natural language. Respondents also indicated the possibility of using surveys, interviews, questionnaires to gather knowledge in the specific area of interest.

Also, the knowledge needed for the operation of software agents enhances organizational knowledge resources. From the point of view of knowledge engineer the resources of knowledge used by the agent should be structured in the machine-readable form, so by definition such vocabulary can be entered into the agent's knowledge base. Such knowledge is frequently extending scenarios of usage that contain threads related to the specific knowledge pools. Threads are grouped into scenarios. We can say that knowledge that is used by the agents is two-folded: a part of it takes a form of vocabulary, and the other part is a knowledge about the scenarios of usage.

#### IV. CONCLUSION

Conducted partial studies indicate that such solutions are now heavily used by organizations and require further consideration in terms of the methodology of agent construction solutions. The studies have shown that companies implementing such solutions do not sufficiently take a methodical approach to the problem of the design and deployment of agents. This is due to the fact that the construction of such solutions requires, on the one hand, to address the issues of software development methods, and on the other theories of knowledge engineering that are required in the context of modeling the knowledge base of agents. This necessitates the search for the new methodologies for the design and construction of such solutions. In particular, in the context of se-

mantic methods of agents' knowledge representation, which should be linked to the information systems of the organization. These issues were highlighted by the participants of this study.

Despite the differences in the details of the methodologies used in the design and the tools used, companies generally agree on the steps of the implementation of agent-based solutions. In simple terms it can be assumed that implementation is based on four main processes. The first one is to analyze and collect information from the user, based on which the knowledge of an agent will be formulated. The information comes from many sources, such as individual interviews, the results of searching through the paper-based and electronic documents. Because such knowledge usually is not codified in clear and understandable manner, it is necessary to systematize the acquired information. Thus the next step is to design a model of the knowledge which will be used to its structuring. Once the information is structured it can be used by an agent to identify the thread and give you the right answers to users' queries. The next step is the implementation of the agent system. The last stage is usually testing the system by the user and getting feedback on its operation. Feedback information allows designers to assess whether the knowledge that has been introduced to the agent is correct, if something has been missed and can be supplemented, if the scope or substance of knowledge has been changed in some way. Then it is necessary to update the knowledge. Despite the use of their own methodologies agent systems' vendors base on proven, UML-based tools. Such tools facilitate modeling of knowledge structures for knowledge bases, allow the ordering of knowledge structures and to describe some of relations in the knowledge base. They are also used when it comes to designing the architecture of agent systems. We can name several of them, both universal, such as Enterprise Architect, Power Designer and Eclipse, the Semantic Works or more specific like Protege for building ontologies. Companies recognize the benefits of using tools like CASE even when they can confirm that their usage has to be preceded by the learning process which poses some difficulties for its users. Consistency in the use of such solutions provides good documentation of its architecture and guarantees the appropriate level of maintainability of the agent system.

The process of building agents using the semantic mechanisms of knowledge representation requires that, at the design stage of the system, it is necessary to determine how the knowledge of agents will be sourced from within the organization and how it will be updated and managed. This requires that the organization, in which this solution is built, has been focused on knowledge management processes, which can support the use of such solutions. Respondents also pointed out that finished implementations allowed to disclose previously unknown places in the organization, in which the domain knowledge is stored. As a result, the process of implementing such a solution should not end with its completion, but requires further improvement of knowl-

edge bases of agents. Although it requires posting staff members to supervise the knowledge base of agents, but it is feasible from the point of view of the organization efficiency because agents can handle multiple clients simultaneously using the resource of codified knowledge. This aspect becomes a vital part of a research in the context of agent solutions, since contemporary methods of their construction are mainly focused on designing their architecture and, in a small percentage, indicate the possibility of modeling the knowledge of the system. The issue of methodological approaches to the modeling of knowledge structures for software agent societies, using the semantic mechanisms of knowledge representation, will be a main focus of authors' further research.

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