THE ROLE OF MULTI-AGENT APPROACH IN BUILDING INFORMATION INFRASTRUCTURE FOR A MODERN COMPANY AND CARRYING OUT MANAGEMENT TASKS

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Abstract: *Companies applying information, communication technologies and computer simulation modeling tools are paying more and more attention to the ability to adaptive and hybrid architectures when building and developing information infrastructure. This paper studies an approach to forming an external information infrastructure for a company with a developed clientele by joining opportunities of CRM (Customer Relationship Management Systems) technologies and intelligent agents. Companies can succeed in carrying out their development strategies by following modern trends, adding intellectual information tools to CRM systems and creating an adaptive hybrid for external infrastructure based on the multi-agent approach.*

Keywords*: Modeling, Multi-Agent systems, Management, Customer Relationship Management systems.*

ACM Classification Keywords*: K. Computing Milieux - K.6 Management of Computing and Information Systems – K.6.4 System Management – Centralization/Decentralization*

Introduction

In modern Russia, using information and communication technologies (ICT) in management, including computer simulation modeling methods and tools, is a key driver of business efficiency. They do this by: helping improve quality of products and services, save labor and material costs, increase productivity, and improve production management. In industrially developed countries, despite a much higher degree of IT penetration in businesses, issues of choice and implementation of modern information systems and business simulation modeling tools that would meet the market demand and business strategies are also vital. Development of companies' external information infrastructure (II) and improvement of customer relations management (CRM) are growing in importance, with intellectual information technologies (IT) developing.

When solving business problems, simulation modeling tools should ensure mutual understanding at all organizational levels and bridge the gap between strategic vision and its implementation. One of the solutions is multi-agent systems (MAS) that have been developing rapidly in the last decade. Modern business simulation modeling tools use special software, programming languages and systems to develop models demonstrating structure of business processes, relations between people and room for optimization in the organizational structure as a whole.

This research studies the application of mobile agent technology to expand CRM possibilities for a growing clientele and comprehensive adaptive information infrastructure. Whereas a client-oriented approach is widely used as an element of business strategy, the agent concept is innovative and developing, and the very idea of integrating MAS and CRM methodologies is quite new.

This issue is undoubtedly important for more and more companies facing the necessity to improve customer relations management and recognizing their need for modern information and communication technologies and approaches.

This paper aims at analyzing applicability and adaptability of the joint CRM and MAS technologies, as well as the formation of comprehensive external information infrastructure for companies with growing clientele.

Thus, the research should study the concept of adaptive infrastructure, its modern technologies, and construction of adaptive infrastructure with multi-agent systems and customer relations management systems.

MAS for Management

Multi-agent systems as systems of distributed artificial intelligence have the following advantages:

- They speed up task fulfillment by parallelism and save the volume of data transmitted by passing high-level partial solutions to other agents;
- They are flexible by using agents of various capacity to carry out a task dynamically in cooperation;
- They are reliable by passing functions from agents unable to carry out a task to other ones.

MAS integration into a company structure can bring the following results:

- An information system specifically adapted to the enterprise's needs.
- More flexibility and ability to adapt to the external environment, especially in uncertainty.
- Ability to search and get unorthodox solutions.
- Confirmation of suppositions that previously lacked information.
- Faster decision-making when modeling negotiations.
- Finding and resolving potential conflicts of interests in both external and internal environment.
- More reliable decisions made owing to the agents' ability to pass functions to one another and redistribute responsibilities, which is not always possible in real life.
- Optimized access to information for all employees.

Major advantages of the multi-agent approach relate to the economic mechanisms of self-organization and evolution that become powerful efficiency drivers and ensure enterprise's stable development and prosperity [Chekinov G., Chekinov S., 2003]. Based on the multi-agent approach, a brand-new intellectual data analysis can be created, open and flexibly adaptive to solve problems, and can be deeply integrated in other systems.

The published feedback on MAS application shows that there are the following areas of agent application:

- distributed or network enterprise management;
- complex and multi-functional logistics;
- virtual organizations and Internet portals that sell products and services;
- academic management in distance-learning systems;
- companies with developed distribution and transportation networks (e.g., Procter&Gamble);
- distribution channels management;
- users' preferences simulation modeling (e.g., Ford).

Big companies can see advantages to the multi-agent approach such as: faster problem solving, less data transmission by passing high-level partial solutions to other agents, faster agreements and order placements.

Distributed companies find primary advantages in improved supply, supervision and coordination of remote divisions and structures. Companies with wide and quickly changing varieties of products can flexibly react to clients' changing preferences and foresee periodic changes. Service companies can preserve their experience of interaction and problem solutions with MAS technologies.

Integrating CRM and Multi-Agent Approach

Methodologies of the client-oriented approach to organization of company operations and the multi-agent approach can be integrated. In other words, CRM strategy can be carried out with multi-agent systems:

- To simulate and forecast clients' behavior, both returning and potential ones';
- To coordinate dealers and remote divisions with a multi-agent system;

- To automate and improve the Customer Support process within the CRM concept;
- To preserve knowledge and skills of marketing and sales specialists in the relevant agents' databases;
- To develop an integrated multi-agent Internet portal for agents to keep users' personal contents;
- To create a search agent to monitor outside information;
- To organize a distance-learning portal.

Here are principal provisions of the methodologies considered in this paper as well as major mechanisms for their implementation that can underlie integration of the approaches:

The CRM concept methodology provisions:

- Systemic approach to customer relationship management;
- Business strategy to efficiently manage customer relationship;
- Client identification, profiling and personalization;
- Assessment of clients and their needs with data analysis and sorting;
- Long-term customer relationship;
- Meeting client's needs;
- Cutting-edge management and information technologies to collect information about clients at every stage of their life-cycles;
- Automation of the three key divisions that are a principal interface between the enterprise and its clients: marketing, sales and service;
- New products based on customers' feedback;
- Every contact with clients fixed and stored in the contact history.

The CRM technology can be implemented with the following mechanisms:

- collecting and processing partners' data in a unified database;
- automating and controlling managers' work;
- timely analyzing efficiency of the enterprise.

The multi-agent approach methodology includes:

- Distributed artificial intelligence methods;
- Human or software agent's impact on environment.
- Program's ability to react to external events and choose relevant actions on its own;
- Forming action plans, forecasting environment changes;
- Social aspect in agents' behavior and their interaction within a multi-agent system;
- Opportunities to transfer data, knowledge, responsibilities and tasks;
- Systemic approach (agents are parts of a single system and carry out a single task);
- Decentralized data, access to them and agent management;
- Negotiation simulation modeling and finding an optimum solution from a conflict of interests.

Mechanisms used by the multi-agent approach include:

- databases on a certain area of life with models of primitive values and relations as well as analysis, learning and situational orientation algorithms;
- agents' cooperation, conflict of interests, economic cooperation methods;
- object-oriented approach;

- agent design standardization, special agent programming languages (e.g., the ACL group – Agent Communication Language).

Interestingly enough, experts note that CRM systems are most efficiently applied, among others, by high-tech and distribution companies. At the same time, distribution and new high-tech services are leading in using multi-agent systems.

Please note that the suggested agent approach is not the only one possible, principal or most efficient to build external II for a company specializing in software development and integration. Yet, it can help the company get the following advantages in management, strategy planning and development:

- more efficient database maintenance gives more clients;
- consistent users of the system get better service;
- lower technical support specialists' workload;
- distance-learning portal attracts more users.

Let us consider an example of a software company whose external infrastructure consists of the following blocks: potential clients; technical support and consultancy; education; sales and dealership. The company strives for long-term contracts, customer loyalty and client-oriented approach. It has a distributed client network all over Russia.

The basic stages to design a MAS for the company are:

1. *To formulate the mission (goal) for the MAS.*

MAS's goal is to build the company's external II to get certain advantages when working with the client network.

2. *To determine MAS agents' principal and additional functions.*

The company should analyze its operations and find the key ones to efficiently manage the client network. The following operations (components of key business processes) impact the client network management and are its major, most important part:

- Working with potential clients and customers;
- Keeping a database of potential and returning clients;
- Working with remote clients;
- Controlling dealers;
- Technical support and consultancy for users;
- Trainings;
- Online user support (keeping users' personal contents on the company's Internet portal);
- Efficiently measuring marketing actions.

3. *To specify agents and distribution of their functions.*

Upon the previous item, the following agents are needed to build a MAS:

- Incoming requests processing agent;
- Potential clients agent;
- Regular customers DB agent;
- Remote clients agent;
- Consulting agents;
- Distance learning agents;
- User agent on the Internet portal;
- Information monitoring search agent.

4. *To determine basic correlations (relations) between MAS agents*

Agents' basic correlations include:

- exchange of information received from external environment and acquired knowledge;

- information transfer from the potential clients agent to the regular customers DB and remote clients agents;
- distribution of incoming requests by the incoming requests processing agent among consulting, potential clients, regular customers DB and remote clients agents;
- distance learning agents' interaction;
- search agent's communication with Internet portal user agents—transfer of appropriate material (user agents create requests to the search agent).

5. *To define possible agents' actions (operations):*
   - communications;
   - interaction with users through a special interface;
   - interaction with users during distance learning;
   - cooperation and efficient distribution of information.
6. *To analyze current or potential changes in the external environment (functioning conditions).*

At present, the most efficient MAS scheme for the company under consideration is a system with an active human involvement. This will be more effective for coordination of actions, efficient management of the client network and better customer relationship is of primary importance. At the same time, such an important aspect as releasing employees' time is not critical, although the issue exists due to a high employee turnover. Among future modification of the MAS suggested, there may be widening the agent network and transferring some functions currently performed by humans to them.

Conclusion

Businesses and ITC are more and more closely interrelated. Like all over the world, IT in Russia is becoming a critical element of the product/service and profit generation chains. Companies' profits are growing with both cost and management optimization, and more clients brought by client-oriented strategies. It is an international II development trend that the CRM technology is getting more and more popular, and companies are allowing customers to form their requirements on their own. Yet, customer relationship management systems are most often built on standard solutions based on CRM modules as connection tools between the ERP system and external environment. CRM technologies in their essence cannot be a comprehensive tool to form information infrastructure of a company developing information interactions in the external environment. That is why it seems very interesting and perspective to study how external II can be built to organize comprehensive client networks with the widely used CRM technology along with a rare but perspective MAS approach. This area is as of yet understudied, however it is developing quickly.

It is no less important that the ability to adapt and hybrid architectures are becoming essential when building II. A company can successfully implement its development strategy by relying on these modern trends, adding intellectual information tools to the CRM, and creating a hybrid adaptive external infrastructure based on the multi-agent approach.

Once again, the suggested approach to building the external information infrastructure for a company with a developed client network, based on joint possibilities of the CRM technology and multi-agent approach, is neither the only one possible nor the most efficient one. Based on the methodologies and mechanisms of the system described, one can find ways to integrate them, although it would not be appropriate to presume the integration full.

The CRM and MAS technologies can be mutually complementary. Both of them offer a certain specific approach to structuring business operations rather than just automating certain single processes. Thus, multi-agent systems are a radical concept that starts an era of network organizations with intellectual robots' collective interaction by offering to switch from powerful centralized systems to fully decentralized ones, with hierarchical structure replaced with network organization, rigid bureaucratic "from top to bottom" management (based on

bosses' commands for subordinates) with negotiations, and planning with flexible agreements. As a result, production volumes, profitability, competitiveness and mobility are growing. The CRM technology also offers a flexible approach to building the whole company's business. The CRM methodology should not be considered just a concept of interaction with clients; it is rather a system that helps build a long-term client-oriented business.

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