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ANALYTICAL REVIEW OF SOFTWARE FOR MULTI-AGENT SYSTEMS AND THEIR APPLICATIONS

Abstract. In this article there was conducted an analytical review of the most common modern software and implemented on their basis practical applications. There is considered the history of development of multi-agent systems (MAS). The relevance of the use of multi-agent technologies for the creation of information systems for the complex objects modeling based on various methods and algorithms is noted. There were considered the most widespread agent-oriented platforms of multi-agent systems, the comparative analysis of their characteristics and presented the development tools was carried out. The examples of modern multi-agent applications implemented with the help of these software products in industry, science and education were presented. The features of applications functioning in the production of goods and services, as well as of complex processes modeling were pointed out. Particular attention is paid to the Java Agent Development Framework (JADE), presented the structure, main functions and methodology of the multi-agent systems development. The advantages of multi-agent systems (flexibility of operation, operational interaction between agents, optimal distribution of computing resources, self-organization and multifunctionality) at creating innovative intellectual technologies based on different approaches applying and on system analysis were shown. There were analyzed the features of agent technologies and prospects of their use for the development of complex multi-user programs.

Keywords: multi-agent systems, analytical review, software.

Introduction. The development of powerful personal computers with high computing productivity and with large memory capacity, as well as the need to process large amounts of information led to the development of new intelligent technologies based on various modern approaches. Multi-agent systems (MAS), in which interacting agents are used for solving complex problems, have become widespread. Many MASs are the basis of large-scale open, decentralized systems, which consist of autonomous components with such features as reactivity, proactivity, and the ability for flexible interactions to achieve their goals [1]. Under the term reactivity of agents, there is meant the ability of agents placed in the environment to perceive this environment and to react to changes occurring in it. Proactivity is the properties of agents in order to solve problems in the environment on their own initiative. In MAS agents interact with each other, and also make independent decisions based on the implementation of certain algorithms to achieve the set goals.

Multi-agent systems have a 40-year history [2, 3]. At the end of 1990, there was a significant interest to self-organizing MAS. A lot of scientific works are devoted to the study of MAS, among which there are works by Ferber J., Schumacher M [4], Roberto A. Flores-Mendez [5], Chavez A. [6], Brooks T., Finin N. Jennings, Wooldridge M., B.I. Gorodetsky, V.B. Tarasova, V.F. Khoroshevsky and others. The most famous works are by Jacques Ferber [7], who was one of the first in France in the 90s to publish works on the MAS. In 2000-2005 there was created a working group "Self-organizing MAS" based on the European project program FP3-5 "AgentLink", which gave a powerful impulse for the researches and development in this field.

The relevance of MAS developing is determined by the need to solve complex problems that are characterized by high complexity of calculations, parameters uncertainty and functioning in real time. The main advantages of MAS are the optimal distribution of computing resources, flexibility (the system can be supplemented and modified), self-organization, self-recovery and fault tolerance, multifunctionality, etc.

The article gives an overview of the main agent-oriented platforms, their advantages and sphere of their application. There are considered the examples of modern software products application implementing a multi-agent approach to real applications in various fields of science and technology. Particular attention is paid to the multi-agent platform JADE, as to the most widespread and open system for the development of MAS. At the end, there is given a conclusion on the results of the analytical review.

Multi-agent platforms review. There is a large number of software implementing the MAS. The most famous platforms are: JADE (Java Agent Development Framework [5]), JACK Intelligent Agents [17], MadKIT (Multi-Agent Development Kit [18]), Agent Builder [23], Cougaar (Cognitive Agent Architecture [27]), Zeus (Agent Building Tool-kit) [34], MASON (Multi-Agent Simulator Of Neighborhoods [36]), etc.

Most of the presented platforms are based on the Java programming language, which allows to develop multi-agent applications on a cross-platform basis, that is, to run the final software product in various operating systems. Each platform has its own characteristics. Most multi-agent platforms have an open license and are distributed free of charge. Paid platforms (for example, Agent Builder) are closed and do not allow to change the initial code. Each software is characterized by its own tools and development models, and also has various applications.

Table 1 presents the most known multi-agent platforms and their characteristics.

Table 1 – Multi-agent platforms

#	Platform	License	Development tools
1	JADE (Java Agent Development Framework)	open (GNU Lesser General Public License)	Agent Management System, Director Facilitor, Agent Communication Channel
2	MadKIT (Multi-Agent Development Kit)	open (CEA CNRS INRIA LogicielLibre)	Agent/Group/Role model, Organization-centered Multiagent System
3	JACK Intelligent Agents	open (Proprietary software)	Belief-Desire-Intention Model, JACK Development Environment (JDE), JACK Object Modeller (JACOB), JACK Plan Language (JPL), Agent Run-time
4	Agent Builder	closed (not free of charge)	Project Control Tools, Ontology Manager, Agency Manager, Agent Manager, Agent Debugger
5	Cougaar (Cognitive Agent Architecture)	open (Cougaar Open Source License)	Blackboard, Http servlet engine, Knowledge representation system
6	Zeus (Agent Building Tool-kit)	open (free initial code)	Three layers of agents, Role Modeling
7	MASON (Multi-Agent Simulator of Neighborhoods)	open (free initial code)	2d and 3d Libraries

1. JADE (Java Agent Development Framework) [5] – a widely used software platform that is an effective tool for the development of applications based on MAS. The platform has three main modules in accordance with FIPA standards (Foundation for Intelligent Physical Agents). Agent Management System AMS controls the registration and authentication of agents, manages the life cycle of all agents within it, and also provides services of white pages (the register of existing agents). The DF (Director Facilitor) module provides yellow page services (the register of agent services registered in the AMS). The third module ACC (Agent Communication Channel) controls the communication between agents. The structural diagram of JADE is shown in figure 1.