Technologies of Intelligence Multiagent Information Proceccing with Blockchain for Management

Vishniakou U.A., Shaya B. H., Al-Masri, A. H., Al-Haji S. K.
Belarusian State University of Informatics and Radioelectronics
Minsk, Belarus
vish2002@list.ru

***Abstract*—The tendencies of using multi-agent intelligent technologies for information processing are given. The main ideas of building a distributed multi-agent system with distributed knowledge and distributed processing are shown. The structure of multi-agent system for monitoring sound information is done. The directions of using multi-agent intelligent systems in management activities using cloud and block chain technologies are presented. As the concept proposed the creation of a distributed tool platform based on multiagent approach, combining semantic and blockchain technology.**

***Keywords*—multi-agent technologies, distributed knowledge bases, distributed decision-making, cloud environment, tool platform**

I. Introduction

Under multi-agent technology is understood the technology of development and use of multi-agent systems (MAS) and multi-agent management (MAM). The problems of control and distributed interaction in networks of dynamic systems attract the attention of a large number of researchers. This is due to the widespread use of multi-agent systems in different areas, including automatic adjustment of parameters of neural recognition networks, transport management, distributed sensor networks, control in communication networks, interaction of UAV groups, management of mobile robots, protection of information resources, etc. Distributed MA systems are used that perform actions in parallel, for which the task is dividing on parts between several computational threads. Such problems arise not only in computer networks, but also in production networks, service networks, transport and logistics networks. With natural constraints on communication, decentralized strategies are able to effectively solve this type of problem [1-3]. Block chain technology is another application layer working on top of the Internet Protocol stack [4]. It is proposed to use distributed block chain tools to control the operation of intelligent MAS.

II. The basis of MAS

Multi-agent systems originated at the intersection of system theory and distributed artificial intelligence. Open, active, developing systems are discussed, in which attention is paid to the processes of interaction of agents for building systems with new qualities. MAS are built as a union of individual intelligent systems based on knowledge [3]. The MAS consists of the following components: a set of agents working with objects; variety of tasks; a space in which there are agents and objects; the set of relations between agents; many agent actions (operations on objects). Agent management system (AMS) is also an agent that controls access and use of the agent platform [1].

The basis of the organization form of interaction between agents characterized by the combination of their efforts to achieve the goal in the division between their functions, roles and responsibilities is cooperation (C). This can be determined:

K = cooperation+ coordination +communication Under the coordination means the management of the associations between actions. Communication between agents depends on the chosen protocol, which is a set of rules that determine how to synthesize meaningful and correct messages.

In the MAC architecture, the main part is the domain-independent core, which includes such components: direct access service (provides direct access to the attributes of agents); message service is responsible for the transmission of messages between agents and kernel systems; agent class library (part of the database) contains the classification of agents in the MAS; agents community, where agents are located (this block provides functions for loading/writing agents and their properties and optimizes the work of agents with resources); ontology is a subject knowledge base containing specific knowledge about objects and environment of functioning, represented in the form of a corresponding semantic network [1, 2].

III. The agent structure and their use

The basis of agent structure is the context, or server environment, in which it is executed. Each agent has a fixed identifier-name. In a server environment, you can run not only the source agent, but also a copy of it. Agents are able to create their own copies, sending them to different servers for execution. When the agent arrives on the next server, its code and data are transferred to the new context and erased at the previous location. In the new context the agent can do anything that is not prohibited there. Upon completion of the work in the context the agent may send itself in a different context or upload sender address. Agents can also shut down

themselves or at the command of the server, which then moves them from the context to the storage location.

The structure of a typical agent includes inputs (internal parameters of the agent and data on the state of the environment), outputs (parameters affecting the environment and informing the user about the state of the environment and decisions made), the solver – the decision-making procedure. The solver can be a fairly simple algorithm or an element of an artificial intelligence system [2].

Multi-agent systems are used for the development of information and industrial systems. In industry the MAS are used to the solution of management automation of complex systems, for the collection and processing of information in games. Multi-agent technologies are applicable in the management of mobile resources, as well as in such areas as object design, industrial production [1].

In sources [5, 6] MAS deals with the application of automate the construction of intelligent knowledge bases and problem solvers. The resulting model of hybrid knowledge bases, which ensures the compatibility of present knowledge and can be represented in knowledge bases multi-level meta knowledge, to structure the knowledge base according to various criteria and to apply components of knowledge bases again [5]. The agent-oriented model of the hybrid solver allows to build variety of MAS: for produc-tion, customer service, construction design [6].

IV. Design of MAS

The general methodology of the ascending evolutionary design of MAC can be represented by a chain: <environment - functions OF Mac – role of agents – relations between agents – basic structures of MAC-modification>. It includes the stages of: formulation of purpose (objectives of development) MAC; the identification of core and support functions of agents; clarify the composition of agents and the distribution of tasks among agents, the choice of the architecture of the agents; the provision of basic relationships between agents; determination of possible actions (operations) agents; analysis of real-life, real or anticipated changes in the environment. When designing, the organization of agents can be considered as a set of roles that are in a certain relationship with each other and interact with each other [1].

MAS bottom-up design methodology requires a preliminary task of the initial functions, determining the range of their obligations to each other, the formation of the initial structures and its developing on the basis of the allocated functions and the study of the adequacy of these structures to the nature of the tasks in the selected problem areas.

The technique of top-down design is to determine the social characteristics of MAS on a set of criteria, the construction of the basic types of their organizations, followed by the definition of requirements for the architecture of agents. For artificial social systems and communities, a top-down approach to organizational design is put forward [2].

Agents can be integrated into cloud computing (CC) structures that contain specific functions for problem solving, data processing, and management. They support a natural mix of knowledge-based information and technology and can support the process of logical reasoning (for example, including business regulations). They enable learning and self-improvement at both the infrastructure level (adaptive routing) and the application level (adaptive user interfaces) [7, 8].

V. MAS standards and platforms

There are several international approaches to creating a MAS, the most famous of them are [1]: MASIF (Object Management Group), which is based on the concept of a mobile agent; FIPA (Foundations for Intelligent Physical Agents) specifications based on the intelligence of the agent, as well as standards developed by the research subsection Defense Advanced Research Projects Agency (DARPA), in particular Control of Agent Based Systems. Regarding mobility and intelligence of agents, most experts agree that mobility is the Central characteristic of the agent, intelligence is desirable, but not always strictly required. [1, 2].

FIPA's activities include joint research and development by its members of international specifications that will maximize the interaction between agent applications, services and equipment. FIPA specifications focus on enabling intelligent agent communication through standardized agent communication and content languages. Along with the General basics of communication, FIPA also specializes in ontology and negotiation protocols to support interaction in specific application areas (transport support, production, multimedia, networking) [1].

The OMG MASIF standard creates conditions for the migration of mobile agents between MAS via standardized CORBA IDL interfaces. DARPA initiated the work on the distribution of Knowledge Sharing Effort, as a result of which the agent programming languages were divided into syntax, semantics and pragmatics: language KIF (Knowledge Interchange Format) – syntax; Ontolingua – language for defining shared ontologies (semantics); KQML (Knowledge Query and Manipulation Language) – a high-level interaction language (pragmatics). When you create a MAS is also used language of communication between agents – Agent Communication Language (ACL) that specifies the types of messages agents, the content and the ontology. Cooperation between agents is achieved through a set of basic concepts used in communications. The ontology is used as the Application Programming Interface and defines the agent interface.

At the technical level, communication between agents is carried out by message transmission using the application layer Protocol (SMTP, TCP/IP, HTTP, IIOP). Alternatives to using ACL are a number of languages such as database languages (SQL), Distributed object systems (CORBA), Service languages, and Web languages (XML, RDF, DAML).

The evolution of agent creation technologies requires: the development of semantics of communication languages of ACL agents, the development of ontology; improving the use of metadata; declarative protocols (languages for the definition of high-level protocols based on more primitive); practical knowledge exchange between agents (mechanisms for the exchange of information and knowledge); the development of schemes and methods for controlling agent sys-tems (artificial markets, natural selection, etc.) [1].

Agent platforms are one of the ways to build distributed systems and allow user to describe and provide access to all applications running on the agent platform to the services they need. The functions of the agent platform include the distribution of agents, audit of their functioning and management.

MAS development is based on the following tools [2]: JADE (Java Agent Development Framework) - software environment for creating multi-agent systems and applications that supports FIPA standards for agents. It includes the agent runtime environment, a library of classes that are used to develop agent systems, a set of graphical utilities for administration and monitoring the life of agents, connected to the project in the Java language. JADE agents can be different: from simple, reacting, to complex - mental. JACK Intelligent Agents is used as a Java platform for creating multi-agent systems. Just like the JADE platform, it extends Java with its classes. JACK is one of the platforms where the model of agents 'logic based on beliefs-desires-intentions (Belief–desire–intention software model - BDI) and built-in formal logical means of agents' work planning are used.

The functionality implemented within the framework of the paradigm block chain can look like an integrated physical level of calculations with many devices, on top of which there is a layer for servicing payments. But it's not just about payments, but about micropayments, a decentralized exchange, earning and spending tokens, getting and transferring digital assets, and drawing up and executing clever contracts - that is a full-fledged economic layer that has not yet been available in the Internet [4].

VI. MAS FOR INFORMATION PROCESSING

The components of a multi-agent system of information defense are intelligent programs (protection agents) that implement the specified functions to provide the required security class. They allow you to implement a comprehensive security system used network software, operating systems and applications, increasing the security of the system to the required level. Within the framework of this research direction, architectures, models and software prototypes of several MAS were developed: attack modeling, intrusion detection, intrusion detection training, etc. [9]. The process of creating multi-agent systems for any subject area, including the protection of information in computer networks, involves the solution of two tasks: (1) the creation of a «system core» of MAS; (2) cloning of software agents and the separation of the generated multi-agent system from the «system core» [1, 9].

The architecture of the MAS intrusion detection (MAID) multiple instances of agents of different types, specialized for solving a subtask of intrusion detection. Agents are distributed among hosts of the protected network, divided by types of tasks and exchange information for making coordinated decisions [9]. The event agent (AE) preprocesses incoming messages to the host, captures important events to protect the information and forwards the selected messages to the appropriate special agents. The identity and authentication agent (AIA) is responsible for identifying the message sources and authenticating them. The access control agent (ACA) regulates users ' access to network resources in accordance with their rights and privacy labels of security objects. The agents AIA and ACA detect unauthorized access to information resources of the host interrupt connections, and processes events that are identified as unauthorized and send messages to the agents to intrusion detection. The agents A-P1 and A-P2 (A-Patterns) are responsible for detecting individual «suspicious» events or obvious facts of intrusion and making decisions regarding the reaction to these events (facts). Intelligent intrusion detection agents IA1 and IA2 implement a higher level of processing and generalization of the detected facts. They make decisions based on reports of detected suspicious behavior and explicit attacks, both from their host agents and from agents of other hosts [9].

VII. MAS FOR SOUND PROCESSING

The multi-agent system for monitoring sound information (MAMS) in the environment are a set of agents for sound transformation, agent for analysis of information received from them and agent for decision-making. MAMS implements the functions to ensure the required class of protection of people (working or living) and allows to implement an environmental safety system. MAMS can handle noise levels in the urban space and help in learning noise pollution of various areas: inside the building, in a public park or around the entire area, increasing the protection of the space to the required level [7].

MAMS implements the functions to ensure the required class of protection of people (working or liv-

ing) and allows implementing an environmental safety system. The classification agent in MAMS can handle noise levels in the urban space and help in learning noise pollution of various areas: inside the building, in a public park or around the entire area, increasing the protection of the space to the required level. A conceptual schema will be automatically enhanced in the transformation agent in order to help in conception and decision making.

VIII. Concept of IMAS development

The paper [10] analyzes the main developments in the field of intelligent control and the main trends in the development of IMAS. As a result, a list of criteria and their values have been defined, which must be met by the is support IA:

- multi-level monitoring of the environment, collecting information about the state of the network from various sources at different levels of monitoring: the level of the network, servers and subsystems;
- adaptability, ability to detect modified implementations of known and new network attacks;
- proactivity, the presence of built-in mechanisms of reaction to the emergence of attacks;
- openness, the ability to add new analyzed resources of the information system;
- type of control. IP map should combine both centralized and distributed management;
- security. IP map should have the means to protect its components.

As a result, the following solutions for intelligent MAS information processing (IMAC IP) are presented:

- structure and composition of IMAC IP includes agents of workstations, servers, routers and networks and allows to draw the conclusion about the state and prospects of protection development;
- the method of making a joint decision by agents, allowing to form the round table of agents, and on the basis of their result analysis of information obtained from various sources, to assess the state of protection as a whole;
- a technique for detecting attacks using multi-agent technologies that allows user to train a multi-agent system to detect attacks and use it to further detect new threats;
- evaluation of the effectiveness of all the proposed methods using the developed software solutions of the intelligent MA platform.

As trends and development concepts for the use of intelligent and block chain technologies in the MAS management (MASM) is proposed:

- improving the architecture of the MASM in cloud environments, providing effective management in the conditions of uncertainty of the information environment;
- development of new management models in CC with IA based on the choice of the optimal response to environmental events;
- improvement of instrumental program complexes for MASM with intellectual support of decision-making and research of efficiency of methods, models and algorithms;
- development of MAS technology of security management for intrusion detection, countering threats of violation of information security, assess the level of security of information in CIS;
- development of theoretical foundations, models and tools of cloud platform for designing intelligent systems of MASM on the basis of semantic technologies;
- development of application software of workstations or sites for managers and marketers using block chain technologies.

IX. Conclusion

1. The first direction of intelligent MAC IP development is the further development of models, methods, architectures and software to solve the problem of adaptation in the environment.

2. The second direction is the development of models, methods, architectures and software for the collection, structuring of information from the environment, the formation of specialized knowledge bases and decision support agent.

3. The third direction is the creation of a cloud-based tool platform for the design of intelligent MACM based on semantic and block chain technologies.

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ИСПОЛЬЗОВАНИЕ ТЕХНОЛОГИИ ИНТЕЛЛЕКТУАЛЬНОЙ МНОГОАГЕНТНОЙ ОБРАБОТКИ ИНФОРМАЦИИ С БЛОКЧЕЙН ДЛЯ СИСТЕМ УПРАВЛЕНИЯ

Вишняков В.А., Шайя Б.Х.,
Эль Масри А.Х., Эль Хаджи С.К.

Приведены тенденции использования многоаген-тных интеллектуальных технологий для обработки информации. Показаны основные идеи построения распределенной многоагентной системы с распре-деленными знаниями и распределенной обработкой. Дана структура многоагентной системы для обработки звуковой информации. Представлены направления использования много-агентных интеллектуальных систем в управлен-ческой деятельности с использованием облачных и блокчейн технологий. В качестве концепции предложено создание инструментальной распреде-ленной платформы на базе многоагентного подхода, объединяющей семантические и блокчейн технологии.

Ключевые слова: многоагентные технологии, распределенные базы знаний, распределенное принятие решений, облачая среда, инструментальная платформа

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