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THE METHODOLOGY OF MULTI-AGENT SYSTEMS: A MODERN STATE AND FUTURE TRENDS

The problems of structural and logic organization, methods and means of multi-agent systems activity are considered. The basic attention is given to questions of cooperation and self-organizing of multi-agent systems. The modern and perspective areas of multi-agent systems application are analysed.

Keywords – multi-agent systems, co-operation, agaptation, self-organization.

1. Introduction

Multi-agent systems (MAS) present modern direction of development of the distributed artificial intelligence systems (DAI). At present it is a promising sphere of researches and applications, which combines concept, ideas and results of many disciplines, including artificial intelligence (AI), informatics, theory of management, making a decision, sociology, economy, philosophy [1], [2].

DAI is a generalization of AI in direction of co-operation of the agent system. Unlike the traditional systems of AI, which study stand-alone agents with the isolated intellect, DAI is concentrated on the agent systems with a collective intellect. Traditional AI is concentrated on cognitive processes within the limits of individuals, and DAI studies social processes in the groups of individuals. While traditional AI examines the systems of developing and making a decision as centralized, DAI examines such systems as decentralized. Successful activity of traditional AI is determined by every agent in particular, and success of DAI is the result of joint efforts of the agent system. And while traditional AI ladles ideas and methods from psychology, DAI uses economics and sociology for this purpose.

Principal reasons of study and application of the MAS is: 1) technological and applied necessities – MAS offer the new method of understanding, management and use of the separated, dynamic, open and heterogenic systems; 2) the MAS offer the natural approach to the construction of the intellectual systems, that is intellect and collaboration are deeply and inalienably linked with each other in social and in the multi-agent systems.

One of stimuli to study the MAS is the development of the Internet, which is a large opened heterogenic environment for the implementation of the distributed stand-alone program systems. For successful work in such an environment program agents must be able to handle two basic tasks – to find each other and co-operate between themselves.

2. Basic Concepts of the MAS

The basic concepts of the MAS are agent and environment. The agent is a stand-alone vehicle or program essence which operates in interests of achievement the aims formulated by user, with starting point of internal forms about an environment. The agent exists in environment, co-operates with an environment and other agents and can change the environment.

The agent, as a rule, is characterized by such properties [1]–[3]: 1) adaptation – an agent has an ability to study; 2) portability – an agent is a separate software component which can accept self-dependent decisions depending on current status of environment; 3) collaboration – an agent can co-operate and form coalitions with other agents for achievement of own aims; 4) intellectuality – agents can own partial knowledge or mechanisms of destroying in a concrete subject domain; 5) communicativeness – agents can socialize with other agents; 6) mobility is a capacity for moving in the environment or passing the code of program agent from one server to another.

The MAS consists of set of interactive stand-alone agents, with additional properties: every agent owns incomplete information about an environment or global purpose of system development; agent management is decentralized; sources given and access to them – distributed; agent co-operation is asynchronous.

3. Self-Organization of the MAS

It is very difficult to build the MAS, in which agents execute actions resulting in realization of the desired project. The unique method to manage this task is to enable the agents to organize themselves, study, co-ordinate and collaborate with each other. Consequently, MAS has to handle the problem of protocol development of concurrence and co-operation of agent work for successful goal achievement. The far-sighted purpose of the MAS consists in development of technology and methodology of intellectual agent work co-ordination. The perspective tools for realization of this purpose are development and application of models and methods of stochastic games which have much in common with the MAS [4].

Agents are the new model of calculations for the separated large, opened and heterogenic technical systems of processing information. In the case of a prior uncertainty in the agent function of such systems it is necessary to lay possibilities of self-organization and self-regulation [4], [5].

Self-organization is an ability to change the functions and structure of the system depending on tasks and external factors, keeping the vital functions or optimum features of work. Self-organization of the MAS takes ideas from biology, physics, chemistry and society system. Self-organization is realized through co-operation, co-ordination, studying and collective agent knowledge. The typical examples of self-organization are the systems, which design the behaviour living organism populations, so-called “artificial life”. The issue of the day is a study of terms and properties of self-organization of the natural systems with the purpose to transfer them on the cybernetic systems with the elements of artificial intelligence.

Self-organization is the basic feature of the MAS because of the stand-aloneness and local co-operation of integral components. A global behaviour of difficult systems is the result of such co-operation between different agents which form the integral system. The main integrated system feature – is an ability to find the solutions of the complicated problems with the help of the collective agents of relatively a simple structure and individual behaviour without a central management or submission.

However, the influence of the surrounding on the real systems, local agent co-operations and distributed managing influences on the environment can result in the unforeseeable or undesirable system behaviour on the whole. The definition of the structural organization and methods of studies of stand-alone agents which would result in their collective self-organization is a key for MAS planning. Taking into account the fact, that MAS function in the conditions of uncertainty, it is very difficult to find the universal solution of this problem. While developing the real MAS, the possibility of self-organization should be tested at the pre-project stage by means of analytical and imitation design.

4. The MAS Applications

The MAS has a wide range of application for handling tasks which can not be solved by the single centralized system in connection with their complication and information uncertainty. Modern applications of the MAS can be found in the areas, where the planning, production, management, diagnosing and logistic tasks are handled. for an example in the electronic trading, where agents buy and sell commodities on behalf of the clients; a management telecommunication networks is in the mode of the real time and agents are responsible for supply of report packages in time; processing information in the informative networks of the Internet type, where agents are responsible for information filtration and collection; optimization of transport threads, where agents are engaged in information interpretation and processing from the senders of the motion control stations; organization of meetings is automated, where agents operate on behalf of the clients, specifying details in relation to a place, time and order of day; the systems of distance studying, where agents give a help in forming of curriculum, give consultations and determine the level of knowledge; electronic entertainments and computer games based on the virtual reality, where

agents are invented with different skills will realize playing strategies against each other or against people; research of social aspects of intellect and design of the difficult social phenomena, role games, organizational structures, where agents take on itself the role of members of natural organizations.

5. Conclusion

The MAS provide: 1) development acceleration and efficiency with the help of asynchronous and parallel agent work; 2) firmness to the errors and endurance (a failure of one or a few agents will not necessarily result in the crash of the whole system, as other agents can sort out their duties); 3) large scale and flexibility (the system can be applied for the decision of large-scale tasks by involving new agents); 4) minimization of losses – as a rule the decentralized system is more cost-effective than centralized system is, because it consists of simple subsystems of low cost; 5) possibility of development and multiple-use – individual agents can be separately projected or improved by the software specialists with possibility of the agent repeated use in various applied scenarios.

The MAS will be able to play a key role in modern and future computer sciences, in development and analysis of social and psychological models and theories of co-operation in human society. The time is near, when social progress and welfare of person, except for traditional values, will be determined also by the amount of own intellectual agents which in virtual space will decide the row of tasks on their behalf.

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