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PROBLEMS OF DEVELOPING THE MULTI AGENT SYSTEMS IN THE TASKS OF MANAGEMENT TECHNOLOGICAL PROCESSES AND PRODUCTIONS

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Abstract: *In this paper several issues related to the development of industrial multi-agent systems within scope of managing complex technological processes and production with taking into account: the variety of solution methods; the availability of variety of information subject to incomplete and dispersed nature of technological processes, uncertainty in models and wide range of time frames for various system tasks and production situations are considered. To show that or the full disclosure of the potential of multi-agent systems reconfigurable production systems with performance adaptation are in demand. The tasks of developing an agent architecture, its functional organization and creating an agent community in distributed computing environments are considered, when the effective organization of interacting entities leads to problem solutions of cooperation, coordination and self-organization, and due actions of agents stimulate the execution of necessary processes.*

Keywords: *multi-agent systems; management of complex technological processes and production; uncertainty in the models of technological processes and measurements; decision-making support; interaction of agents as software entities; the life cycle of the system; object-oriented programming.*

Introduction

Nowadays the complex industrial objects are characterized by large sizes, complexity of the processes occurring, dynamics of components and as well presence of heterogeneous information for processing; this is due to factors such as maintenance, the management of complex technological equipment and processes, the integrated functioning of the system to ensure staff performance, the impact on the environment, the timely delivery of quality products, etc.

In the paper [1] the aspects and tendencies of industrial automation, defined as actual subjects and areas in the problems of research and development of management systems of technological processes and production, taking into account peculiarities in part of adequate modeling, estimation of functioning parameters, optimization of processes involved in realization of certain systems are presented. The given material allows demonstrate, how to complicate and difficult to description as models can be processes occurring in the environment of industrial automation. As shown in the work, industrial automation is defined as the association of all machines, processing systems, test installations and production sites, which become automated due to technological progress, which development on a global scale due to a largely growing economy around the world.

The growth of the technological segment of many industrial and industrial enterprises stimulates the global growth of the industrial automation market: products and solutions of industrial automation are produced in large varieties, each of which differs from the other by type of automation, control-measuring devices, the exact computers, analyzers, operation and geographical scale. Such factors pose serious problems in the development and implementation of the system for the management of production lines and complexes in different operating conditions. One of the approaches used in this connection in industrial automation systems are multi-agent systems (MAS) and artificial intelligence tools for the developing of intelligent real-time control systems and for complex management and control of industrial objects.

1. Problems of developing of industrial multi-agent systems

Let's consider some aspects of development of industrial multi-agent systems. Industrial MAS are of great importance in conditions of complex technological installations, providing conditions of higher profitability and better management. Despite the existence of sufficiently well-developed methods and approaches in this area, the development of such systems has many unresolved issues related to the following:

• A variety of solution methods where several approaches to the main task of the industrial objects management system are available: for instance, fault detection and isolation can be performed on the basis of models using quantitative and qualitative diagnostics of malfunctions or direct methods of diagnostics; it can uses several methods of artificial intelligence (for instance, expert systems based on rules). These methods are diverse in nature and use certain assumptions about process and performance requirements, the analysis of the accuracy, consistency and stability of integrated systems and so on, consequently, determining the best approaches for performing individual tasks of management for industrial objects will difficult.

• The availability of a variety information related to the incomplete and dispersed nature of technological processes: various instructions and process manuals, experience, process models and current data. All this requires methods of integrating the sources of information and knowledge into a form that can be effectively used in the management system.

• Uncertainty in the models of processes and measurements that may affect the performance of a complex system of industrial objects: most of the system's tasks depend on the exact measurement process (sensor measurement, process disruption due to non-linear dynamics of chemical processes, etc., can serve as a source of system failure). Systematic analysis of such uncertainties and their impact on system performance will be necessary.

• A wide-ranging time frame for various system tasks and work situations that may occur in the workplace (some operational situations may develop within a few minutes, while others are within several hours or days, some system tasks can be performed within milliseconds, while other tasks can take minutes or hours).

For a more visual study of the above factors, let's turn to the principles of the abnormal event Guidance and Information System (AEGIS) of the Honeywell ASM consortium. The AEGIS architecture is based on the next generation intelligent control system to support the operator [2]. This solution has been successfully demonstrated in the lab test environment for the feasibility and validity of the collaborative solution support technologies. Under tested in an industrial environment, the focus was on diagnosing anomalies and their early warning, as well as evaluating and learning from experience. The team of the AEGIS research program has achieved certain goals, including the formation of a culture of situational management and awareness of management situations, conducting extensive consultations, research and cooperation with leaders in the oil and gas industry. It is possible to note such achievements of 12-year research program AEGIS Honeywell in this direction, as: the improved user interface, reduction of the information on emergency situations on 35% by introduction of the new philosophy of reconfiguration signaling, integration of operating procedures, monitoring of equipment by means of intelligent sensor integration, early detection of errors. Despite this, there are some problematic moments in terms of minimizing the workload (information support of technological process), namely, associated with full automation in the interpretation of massive data, the presence of intelligent decision support methods and a number of others.

For other examples it is useful to refer to the work [3], which provides a good overview of industrial implementations of systems, indicating the possibilities of MAS for different tasks.

On the basis of the peculiarities of management systems development, as shown above in the examples, it can be noted that despite the fact that there are implementations of reconfigurable systems in industrial production, there is a lack of knowledge-based methods and intelligent tools for optimal deployment, management and control of their operation. The current methods and approaches in evaluating the functioning of production systems are mainly based on the use of traditional methods in flexible production systems are sufficiently anti-vibration, lack intelligence and learning opportunities. For the «disclosure» of the full (technological, operational) potential of such systems, modular reconfigurable production systems are required with the adaptation of performance for the optimal production solution and for the assigned tasks.

2. Multi-agent systems in the tasks of management technological processes and productions

Obviously, that providing the functioning of a complex technological system requires adequate methods of interaction between components. The theory and practice of research in this direction (including software engineering) shows that in order to solve this problem, the methods of interaction between agents and agent systems have proved to be quite a complete tool, to develop and standardize both the architecture and the interaction languages of the agents [4.5]. MAS as one of the directions in modern information technologies forms the field of research and development, in which is accepted to distinguish three main directions [6]: agents and MAS as concepts of conceptual design (with emphasis on modularity); agents and MAS as a source of technology (with an emphasis on interaction as a principle of computation and decision-making); agents and MAS as a simulation tool (with a focus on the autonomous behavior of a component that interacts on a protocol basis). The theoretical basis of these directions to date take various theories of agents and MAS, furthermore each of them has its own expressive capabilities, determines the complexity of the conceptual model of the agent and MAS, each requires development specialized technology and tools to support application design and programming processes.

The agent in the classic view is-an autonomous computer program, which is capable of purposeful behavior in a dynamic, unpredictably changing external environment. MAS, as a network of loosely coupled solvers of private problems (agents) that exist in a common environment and interact with each other to achieve the goals of the system is defined. Interaction can be performed by agents either directly through messaging or indirectly, when some agents perceive the presence of other agents through changes in the external environment they interact with.

In general, an agent is a computational system that is located in a certain environment and is capable of performing an autonomous activity in that environment to achieve the objectives of the system (development). In this case, the presence of agents as programmatic entities involves two types of tasks or problematic situations from the developer's point of view:

1. What should be developed agent capable of independent, autonomous action for successful implementation assigned tasks: it is a problem of development of the *architecture of the agent, its functional organization.*

2. What should be the interaction of some agents with others in order to successfully perform the assigned tasks: *the problem of organization of the community of agents (MAS).*

In distributed computing environments of technological production, both situations should be considered, when an effective organization of interacting entities leads to the solution of a problem in a distributed computing environment (for instance, for cooperation, coordination, self-organization in the system) and the proper actions of agents stimulate the execution of processes.

In works [6-8] the possibilities of MAS-technologies are analyzed and it is noted that the time of transition from their system-wide application in distributed systems – to creation of really complex adaptive systems, realized on the basis of principles self-organization, for solving complex, multi-criteria, poorly formalized and computationally laborious tasks in the real time. Along with the conceptual and algorithmic problems, indicated in this work, the specific technological problems peculiar to systems using local mechanisms of the organization and evolutionary calculations are specified. As shown in [6], under create a MAS, that solves the tasks of allocating, planning, optimizing, and controlling the use of resources on a multitude objects, forming a network, there are often effects and problems, that make it difficult to find a solution that is related, in particular, it is difficult to assess the current solution from a dynamically changing «optimal» solution; dependence of the decision on the background, for instance, on the order of occurrence of certain events, which is usually caused by the dynamics of the object of control and non-linearity of the most controlled object and non-linear management; slowing the response of the system in case of a long chain of changes to the object management and a number of others. In other words, for the productive development of MAS becomes necessary to change the basic paradigm of formalizing the model of the agent and information and communication infrastructure, providing the maintenance of its life cycle, its interaction with the external environment (including cloud services) in order to achieve the computational efficiency of the model in the real time.

In this regard, it is advisable to propose and test new approaches to formalizing MAS, with a rich component of interaction and extensive use of the principles of the self-organization and evolution inherent in living systems. One of these alternatives is suggested below.

At interaction of components in the distributed structures there are parametric and structural changes both in functional subsystems and in intersystem information connections. Complex functional and informational connections between separate subsystems allow under certain conditions to reconfigure both on the structural and at the information level, providing adaptability to the essential changes environment. Wherein the achievement of properties can be carried out either by change of characteristics of separate subsystems, that is, by parametric adaptation or by change of structure of information connections between separate subsystems and formation of new system structures that is by means of the self-organization. The directions of information links in the implementation of these mechanisms and their possible diversity predetermines the complexity of the interacting processes, for the description of which it is proposed to use distributed associative processes, as concepts of the theory of associative media; with the functional interaction of the components of the distributed network, it is possible to determine the so-called associativity, on the basis of which it is possible to influence the process of information exchange [9]. Such opportunity can be demonstrated for the agent architecture specified is shown in Figure 1: agents in MAS can be defined as conceptual entities that perceive and act in active or reactive mode in an environment where other agents exist and interact with each other based on general knowledge of information exchange. Each agent contains processes for generating behaviors, world models (environments), sensor processing, and value decisions along with database knowledge.

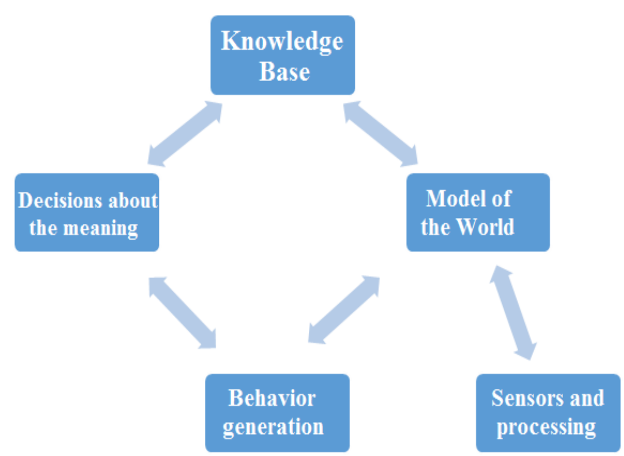

Figure 1. ***Agent Architecture***

In the principles of object-oriented programming, the computation process is understood as a system consisting of modules that interact with each other and have their own methods of processing messages. Given the architectural representation of distributed network computing (set of structures) and the position of agent technologies, such modules have activity are displayed by agents and have mechanisms goal-setting: by dint of concepts of beliefs, intentions, desires, decisions, etc., the agent acts as an active subject (entity), depends on the environment, including the purposes and intentions of other agents.

With the aim to improve the MAS, it is necessary to define a universal format (language) of presentation of technological data and knowledge. To strengthen the semantics of the format and to take into account the specifics of associative interaction, to present technological data and knowledge it is expedient to use the methodology of virtual string space of technological data [10]. The concepts used in this theory, such as the search image (in the design mode, a table with the specific data needed in a particular situation, with the establishment of rules of limitations on the search image, which includes, for instance, external data names), logical functions, etc., allow to present data and knowledge in the symbolic form, which is an undoubted advantage under creating a MAS for technological purpose.

Conclusion

For formalizing the above relations and assess their feasibility additional efforts will be required, which apparently to be the subject of further research and to indicate the topic of subsequent publications, that in general help to realize the new principles in development of qualitatively new instruments of creation of MAS, with considering into account self-behavioral model (as basic principle of management and solution of complex problems) of agents and their interaction.

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