A Conceptual Agent-Based Model to Supporting the Production Equipment Technical Service and Repair Organization

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Abstract

The paper presents a solution of the maintenance and repair organization (MRO) problem based on multi-agent technology. A generalized model of intelligent agent activity in road maintenance and repair techniques developed. An analysis of existing architectures agents has been executed. The hybrid InteRRaP agent architecture with internal simulation subsystem constituting a simulation engine described (it is a complex system dynamic models). The agent simulation apparatus implementation approaches based on the system-dynamic models in the multiagent environment proposed. The structure, basic subsystems and mechanisms of agents’ interaction described. The stages of the continuous organizational process of production equipment maintenance and repair are shown. The proposed system allows obtaining more rational MRO.

Keywords: supporting; monitoring; knowledge; equipment; maintenance and repair; maintenance and repair organization (MRO); decision support; agent-based model; agents architectures; multiagent system (MAS); simulation.

1. Introduction

As you know, the cost of equipment is a big part in the cost of any project, so quality data management system of the equipment leads to a substantial positive economic effect. It is therefore necessary to establish quality moni-
To solve this problem and create a convenient system monitoring equipment was used multi-agent approach. Real-time information comes from all agents that installed on the most important parts of the equipment. This information passes up the agent hierarchy. Deciding occurs in real time. The formalizing the knowledge base features and data storage equipment was used.

2. Model of multi-agents MRO system by example of road construction machinery area

The approach used in this paper is that the solution of MRO can be distributed among the intelligent agents that specialize in solving particular problems. Parallel operation of such agents can significantly speed up the processing of information and improve the reliability of the original problem. In solving this problem are special coordinator agent that can take collective decisions based on local decisions of other agents using the principles of the theory of decision-making or different voting procedures. All local decisions are made in parallel, which speeds up the adoption of a collective decision.

For monitoring of interaction and simplify the management structure similar objects used agents are grouped in multi-agent systems (MAS). MAS model, originally developed to represent the processes of interaction set of objects similar structure has been used successful in a variety of scientific fields [1]. Using this model in the fields of robotics and data mining has led to the development of the concept of an agent as an object endowed with rights of the user and the ability to perform a similar range of applications. Thus, the agent is a complex system based on fuzzy sets.

Due to the heterogeneity and different geographic location of road-building machinery and equipment it is a justified application of agent technology to address maintenance and repair [2]. Agents have characteristics that make them indispensable in MRO problems [3]. Ability to respond appropriately to dynamically changing conditions makes multi-agent systems (MAS) for flexible use in road maintenance equipment, as road repair machine is quite self-contained and the situation it changes dynamically. Agents have properties of flexibility, extensibility, and fault tolerance. In task distributed among the MAS agents, each of which is considered as a member of the group or organization. Distribution of tasks involves assigning roles to each member of the group, the definition of measures of responsibility and experience requirements [4,5].

For all methods of making predictions MRO work equipment within the automated system using agents can improve the speed and quality of drafting plans for work on equipment maintenance and repair. Accordingly, we propose the following model of the multi-system Maintenance [6,7].

Distributed problem solving by several agents in the multi-agent system is broken down into the following steps:

1. Agent Manager Machines analyzes the failures of internal nodes, as well as prioritization of their repair.
2. These tasks are distributed among the agents executing.
3. Each agent Executive decides its task, sometimes also dividing it into subtask.
4. To provide an overall result produced composition, integration of partial results corresponding to the selected task.
5. Agent Manager machine is used to determine the priority for repair of road-building machinery, based on the importance of grades, which were prepared according to the modified methodology RCM2 [8,9].

For the program system of intelligent agents’ implementation have been proposed different agent architectures. For this task selected InteRRaP MAS architecture. In this architecture, source control agent is layered. Each upper layer works with more abstracted (and aggregated) information [10].

Decision Support System (DSS) is a type of computer information systems to assist in decision making for solving poorly structured problems through direct dialogue with the machine using the data, knowledge and mathematical models. DSS, as a rule, are the result of multidisciplinary research, including database theory, artificial intelligence, interactive computer systems and simulation techniques. Decision problems can be classified on the specifics of the information used in particular by the form and nature of the information, depending on the availability of information on the time and the degree of certainty of information [11].

Decision support system is realized based on operational data processing technologies (On-Line Analytical Processing - OLAP). OLAP advantage is that, unlike the classical methods of search queries is formed not on the basis of hard-coded (or require modification for programmer intervention and hence time, that is about the efficiency we cannot go) forms, and with flexible ad hoc approaches. OLAP provides detection of associations, patterns, trends, classification, generalization or detail, forecasting, i.e. provides a tool for the management of the enterprise in real
The essence of OLAP is the formation and subsequent use for the analysis of pre-processed data sets, which are also called pre-computed indices. Their construction is possible based on one fundamental assumption - as a means of decision-making. OLAP does not work with the operational databases and archives with strategic differing lower refresh rates, integration, chronologic and subject orientation. It is the immutability of data and allows them to calculate the intermediate representation, accelerating the analysis of huge volumes of information. [12]

To date, developed software is the base for developed complex automated systems. The first system is designed for the implementation of complex communication throughout the information space MRO road equipment. It is cross-platform application, the client part that can run on both operating systems of personal computers, mobile OS.
3. Conceptual model of agent

In this paper, it will be understood by an agent independent intelligent system capable of taking effect from the outside world and from their own kind, to determine their reaction to this action and to carry out this reaction, as well as acting on behalf of either the user or on behalf of delegated powers agent to perform certain actions.

The main difference between agents from systems in general is the activity that is an opportunity to take any action. Furthermore, the agent is not generally regarded as an aggregate of parts, as a single entity, whereas, for example, in the study of the first system it is the basic approach. Another distinguishing characteristic is that the agent cannot be implemented in the form of a material object, and exist as a standalone program. Furthermore, this program without affecting the material world (while remaining within the computer or computer system) can perform useful actions.

By agents must meet the following basic requirements characteristic [13]:

- **Autonomy.** Agent is able to operate without direct human intervention, self-tracking the environment and their own parameters.
- **Reactivity.** Agent is able to perceive the environment and adequately respond to it.
- **Pro-active.** Agent has purposeful behavior and may take the initiative.

In addition, for the performance of certain tasks agents must meet additional requirements classifying [14]:

- **Ability to communicate.** The agent must be able to communicate and interact with other agents or people.
- **Simulation of the situation.** This is agent's ability to simulate the evolution of the situation, to predict the course of its development.
- **Mobility.** The agent must be able to change its position in the environment.
- **Intelligence.** The agent must be able to conduct inference for a decision on their next steps.
- **Binding to the environment.** Agent must exist in a particular environment (real or virtual).

The proposed hybrid architecture agents is an extension of the existing hybrid InteRRap-the architecture of the agent by adding in her composition of the subsystem simulation, representing a simulation system (complex system dynamic models), with which the agents are able to simulate scenarios for the development of individual innovative projects.

As a means of implementation of simulation unit are encouraged to use the system-dynamic model. This subsystem emulates the behaviour of objects of the external environment and the agent that is used to explain the current behaviour and prediction of possible behaviour in the future. Simulation device is a full or simplified model of the environment in which it is operating agent, recurrently called in the modelling process.

General view of the hybrid architecture of intelligent agent with simulation apparatus is represented on Fig. 2. Its main architectural components include: mental subsystem modelling subsystem of analysis and planning, reactive subsystem communication and interaction.

Mental subsystem is implemented using language KIF (Knowledge Interchange Format) and is interpreted as an intelligent knowledge-based, part of the Autonomous agent, his "Brain" or "Intelligence". Perceived by the agent information is aggregated and reduced engine perception and sent to a mental processing subsystem.

Subsystem simulation is a full or simplified model of the environment in which it is operating agent, recurrently called in the modelling process. As a means of implementation of simulation apparatus are used in work of system dynamic model. This subsystem emulates the behaviour of objects of the external environment and the agent that is used to explain the current behaviour and prediction of possible behaviour in the future.

Subsystem of analysis and action planning, as well as Reactive subsystem are implemented using standard languages describe the behaviour of agents - algebras of action and algebra behaviours. Subsystem of analysis and planning generates, and takes partial remodels action plans agent, and includes the planning mechanism, allowing to build local plans of the agent.

Reactive subsystem defines the ability of the agent to respond quickly to events outside world, as well as events allocated subsystem of analysis and planning, even if they had not previously planned.

Subsystem communications and subsystem Metacentre interaction is implemented through language ACL (Agent Communication Language), based on the theory of speech acts that supports declarative approach to knowledge transfer.
Receptors are sensors agent responsible for the perception agent information, received from the external world (the environment in which you operate the system agents) and from other agents.

Effectors sensors agent, through which the agent acts on the outside world (for example, by changing the parameters of the environment), and other agents, are sending them messages of different content.
The environment is a virtual world in which operates the agent interacting with other agents of the system associated with the real external world [15].

4. Findings and results

The structure of the repair and maintenance organization using multi-agent systems was developed. The choice of agent technologies for solving MRO was executed. The composition of agents and agent-based multi-agent system planning maintenance model was designed. The structure of intelligent agents corresponding to the model was built. The hybrid InteRRaP agent architecture with internal simulation subsystem constituting a simulation engine (complex system dynamic models) was adopted for using in MRO modeling. The model approbation was executed in the area of road construction machinery and oil refining.

Implementation of developed system was carried out on the basis of the regional state enterprise for the roads construction and repair, and repair service contractor enterprise performing the maintenance and repair of different industrial equipment. Currently automated supporting maintenance and repair system collects information on the operation, which is accounted for in the prototype of decision support system.

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References

