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Repair and Maintenance Organization with the Use of Ontologies and Multi-agent Systems on the Road Sector Example

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Abstract: In this paper we define problems and objectives of the effective equipment operation organization and its maintenance and repair (MaR) on the example of road-building equipment (RBE). We propose approach to providing decision-making support (DMS) in the road vehicles maintenance and repair management, based on a modified approach, Reliability-Centered Maintenance (RCM), ontology and multi-agent approach. We studied the dependence of the production losses from the total maintenance and repairs. We define the structure of the repairs and maintenance organization system in the road sector with the use of ontologies and multi-agent systems. We develop the software system structure, designed to support decision-making (DMSIS), on the basis of agents as a multi-agent system, composition and structure of intelligent agents. We describe the development and implementation results of integrated modules of road-building machinery maintenance and repair software-organizational system.

Key words: System planning support • Road construction machinery • Maintenance and repair • Machine maintenance • MaR • MaR organization • Ontologies and intelligent agents • Multi-agent system • RCM2 • Case base reasoning (CBR).

INTRODUCTION

The road sector is important for any country. According to [1], one of the road sector modernization objectives is to improve the management technologies, which include the best of modern approaches to the equipment maintenance and repair (MaR) organization, to provide road repair machinery maximum performance in production program. For many companies road equipment park is not updated sufficiently, causing it to wear and vehicle resource work out [2]. The most obvious solution, at first glance, is to update the equipment to replace the exhaust. However, the economic feasibility of such operations is not always convincing. A more promising solution for challenge is a development of the apparatus for the organization of the organization, planning and decision-making support system for maintenance and repair of road-building machinery.

During the equipment life cycle, such a useful information as the data on the methods and conditions of equipment use it stored, on which you can predict equipment failure, designers will be able to see the equipment shortcomings and users will be able to receive accurate information about the equipment condition [3].

Decision on the Mar Organization: In many industries, approach Reliability-Centered Maintenance (RCM) was proven, in which the value of an asset is determined as well as the consequences of its failure. [14] By the organization of road equipment MaR we can also use RCM (Fig. 1).

In general, the MaR costs are equal to the sum of operating costs and production losses [4, 5] (including the failure of the organization to customers). This curve has the optimum point (Fig. 2). This dependence meaning in that at a certain value of total cost, an optimum value of cost and effect from repair activities is provided. A further investment may increase the effect, understood, such as the rate of plant availability.

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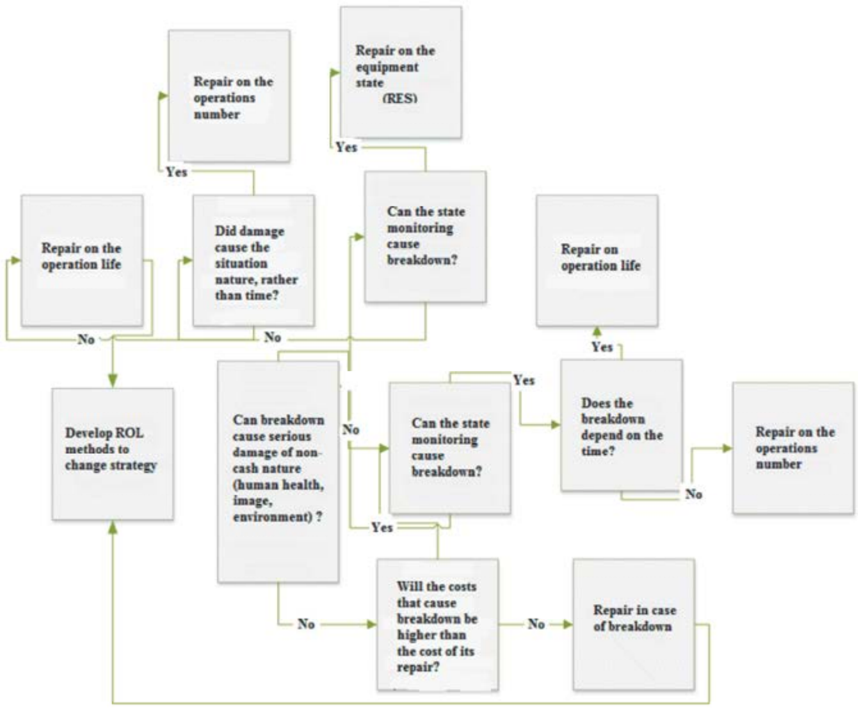

Fig. 1: RCM approach logic

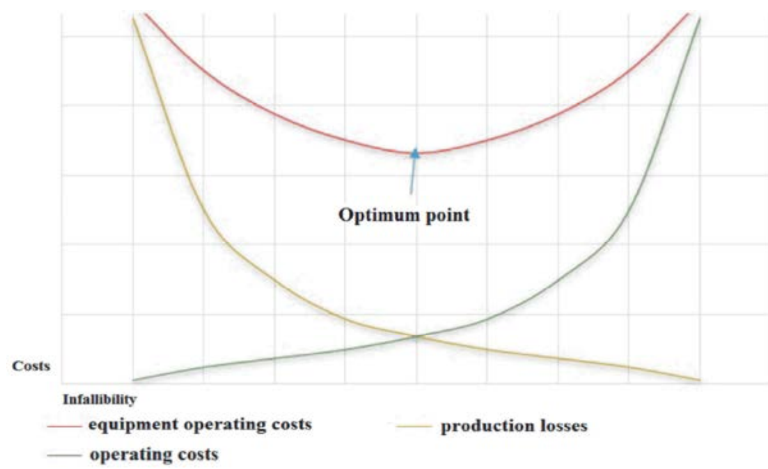

Fig. 2: The dependence of the production losses from the total cost of maintenance and repairs.

The analysis of this relationship leads to the conclusion that the maintenance and repairs management is possible to develop an optimal by cost / benefit plan of work that is essential for the success of the entire range of repair activities. The plan is dynamically changeable. Its adjustment should be carried out periodically.

To increase the road maintenance technological process efficiency it is necessary to automate technology, using an upgraded strategy RCM2 [6] and MaR organization principles, proposed in [7 and 8].

To do this we propose approach to decision making support (DMS) in the road machinery MaR management. Decision-Making Support System (DMSS) is designed to perform the following functions: planning of road machinery MaR, road machinery MaR prioritization, as well as their constituent nodes. Given the domain specificity, DMS system architecture, in the conduct of road repairing works, was built (Figure 4). Modules of offered DMSS are knowledge base (ontology), the database system and the functional modules (for monitoring the current state of technology, DMS, etc.).

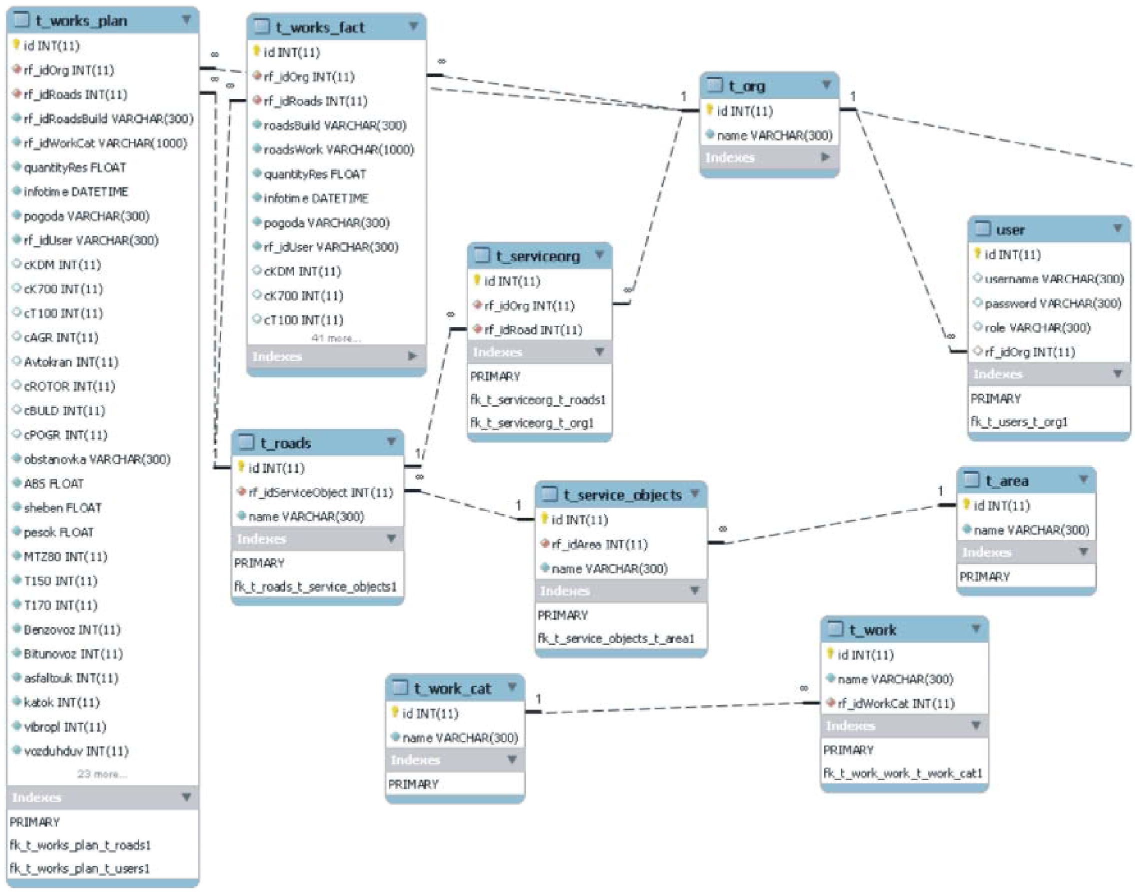

Fig. 3: MaR ontology

In [9] describes five basic concepts of ontology software life cycle - product, process, resource, rule, business. Based on this ontology is built, as shown in (Figure 3).

Ontology is built, according to the standards MIMISA OSAEI (Open System Architecture for Enterprise Application Integration) [10] standard of information about the equipment providing, including the physical configuration of the platform, reliability, condition and platform maintenance.

The system database and ontology are regularly updated. Ontology is regularly updated with new knowledge of professionals, who come into the road vehicles MaR process control system. These requirements are analyzed by expert with the help of DMSS on consistency and stored in the form of new knowledge fragments, which are used to support decision-making and evaluation of road machinery maintenance management process quality.

Multi-agent system model of road construction machinery MaR

For monitoring, interaction and to simplify the management of objects with similar structures, agents, grouped in multi-agent systems (MAS) are used. MAS model, originally developed to represent the interaction of a similar structure objects set, has been used successfully in a variety of industries. [10,11] The use of this model in the robotics and data mining fields has led to the agent concept development, as an object, endowed with the rights of the user and is able to commit a similar range of applications. Thus, the agent is a complex system, which can be based on intelligent methods in multi-agent system interaction.

Due to the heterogeneity and different geographic location of road construction machinery and equipment, application of agent technology to solve the MaR problems is justified. Agents have characteristics that make them indispensable to the MaR tasks. The ability to appropriately react to dynamically changing conditions make multi-agent systems (MAS) flexible for use it in road equipment maintenance, as road repair machine is quite autonomous and the situation there is

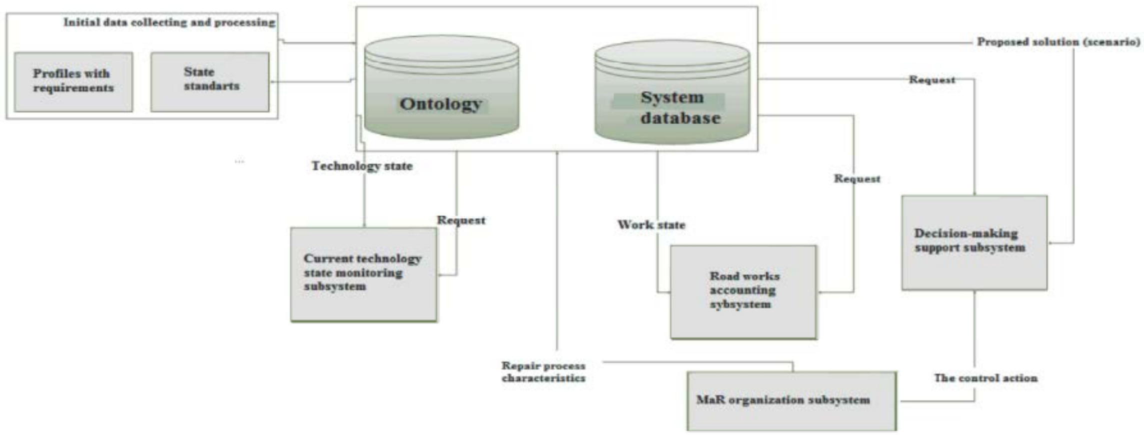

Fig. 4: DMSS scheme

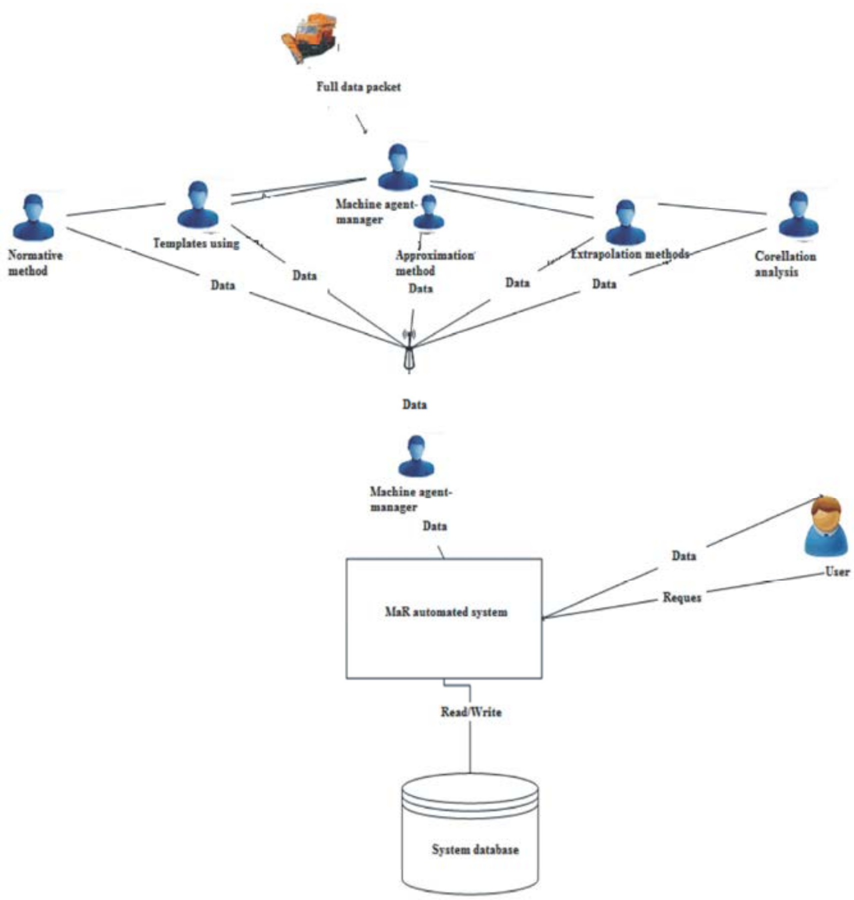

Fig. 5: Road machinery MaR architecture, based on multi-agents

changing dynamically. Agents have properties of flexibility, extensibility and fault tolerance. In MAS tasks distributed between the agents, each of which is considered as a group or organization member. The distribution of tasks involves assigning roles to each group member, the responsibility and experience requirements measures definition. The most promising for the purpose of collecting, analyzing information and decision-making support is seen using BDI-agents [12, 13].

By using equipment MaR works forming forecasts methods as part of an automated system, using agents, we can improve the speed and quality of the MaR equipment work plans preparation. On the basis of [14-17] we proposed the following model of multi-agent MaR system.

Distributed Problem, Solving by Several Agents, Is Divided into the Following Steps:

- machine agent-manager analyzes the failures of internal nodes, as well as repairs prioritization;
- these tasks are distributed among the executing agents;
- each executive agent completes their task, sometimes also dividing it into sub-tasks;
- composition, integration of partial results corresponding to the selected task;
- machine agent-manager is used to determine the priority for road-building machinery repair, based on a importance scale, which is obtained by the RCM methodology [19, 20].

To organize the withdrawal of MaR planning recurring tasks Case Based Reasoning (CBR) method is used [18]. If the regularity principle is not satisfied, then the nodes maintenance and repair priority is produced on the basis of preliminary expert assessment of the node importance and the rules of MaR and other knowledge about the MaR organization process [21, 22].

After successful completion of the node MaR planned operation, information about this case is stored in the knowledge base and in the future it is possible to use it for CBR method work planning [23].

CONCLUSIONS

We perform analysis of the problems and problem setting for the road machinery MaR organization in the road sector. We define the basic methodology for the creation of MaR organization system in the road sector (service on the actual condition, planned preventative maintenance and RCM). Within the work we propose approach to support decision making (DMS) in the road vehicles MaR managemen, based on the adapted and modernized RCM2 method. We have shown that the cost of MaR is equal to the sum of operating costs and production losses.

We define the structure of the repairs and maintenance organization system in the road sector with the use of ontologies and multi-agent systems. We have shown the decisions on the ontology application for MaR organization knowledge management tasks. We produced justification for the use of agent-based technology to address MaR problems. We developed agent structure and MaR planning system, based on agents as multi-agent system. Structure of intelligent agents, corresponding model, was built. For MaR scheduling tasks, we use method of Case Based Reasoning for output to ontology.

Implementation of the system is based on the regional state-owned build and repair roads enterprise. Development and implementation of integrated software -organizational system is performed in stages. At the moment, with the economic effect, company roadwork accounting automated system was introduced and we collect information on work carried out, which is considered as the prototype of the DMSS system.

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