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CONTROLLING OF THE HIERARCHICAL OBJECT BASED ON THE PRODUCTION MODEL

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Abstract. *Due to the increasing complexity of the architecture and algorithms of industrial dispatching control systems (IDCS), generally accepted control methods don't allow to guarantee absolute correctness and sufficient speed automation object's functioning. Therefore, development of methods to improve these indicators is an urgent task and has practical significance. The purpose of the work is to present a method of automated control of dynamic IDCS based on a production model. Conclusions: 1) four-level IDCS's architecture is defined, which allows to implement the functioning of complex hierarchical automation objects; 2) three-level production system architecture is presented for the system level of automation, and two-level production system architecture for automated control at the main server level; 3) proposed method is tested and its advantages over the generally accepted finite state machine method are determined: an increase in correctness by 16% and an increase in the share of fully automated actions by 15%.*

Keywords: *production system, industrial dispatching control systems, inference system, CLIPS.*

Problem statement and its relevance. The rapid development of hardware for industrial dispatching control systems (IDCS) has led to a complication of the architecture and algorithms of their operation. At the same time, generally accepted methods of controlling such systems, such as the finite state machine method or mathematical algorithms, are losing their effectiveness. To solve this problem, control methods based on artificial intelligence are beginning to be used. Already today, neural networks and fuzzy logic methods are used as parts of many industrial systems. However, in the case of complex control of strictly algorithmized objects, their use can lead to a large number of errors due to insufficiently high accuracy of work. The use of production systems on such objects gives better results, but implementation according to basic models does not provide sufficient speed of determining the control action. That is why further research for the implementation of a distributed component-oriented production control system for dynamic IDCS is relevant and has practical significance.

Analysis of recent research. Today, dynamic IDCSs are the most common in industrial automation. In [1], such systems were considered and a method of controlling them based on mathematical algorithms was presented. However, such an approach cannot always be implemented for controlling complex hierarchical complexes, since it requires solving higher-order differential equations, which leads to a significant slowdown in the operation of these systems. The use of artificial intelligence methods is more appropriate for this problem. In [2], a complex hierarchical groundwater resource management system under climate change conditions was presented based on the CNN-Bi LTM network. The authors achieved a high level of accuracy and speed on the task, however, the use of neural networks for strict control systems can lead to emergency situations due to their excessive flexibility and insufficient accuracy. The use of production systems for control allows to solve this problem. In [3], a method of controlling traffic lights based on a production model was presented. The results obtained showed high accuracy, speed and reliability of the proposed method. In [4], the use of CLIPS was proposed for modeling the operation of complex hierarchical IDCSs and the use of production models for controlling such systems was identified as a priority area of research.

Existing methods do not reflect the specifics of a control object with a complex distributed hierarchical structure. Therefore, the implementation of IDCSs and production control systems for them, taking into account the conditions of distribution and hierarchy of control objects, is a necessary condition for ensuring the correctness of their operation.

The purpose of the work is to present a method for automated control of dynamic IDCS based on a production model.

1. IDCS architecture. To implement a distributed component-oriented production system, the IDCS architecture is used, which consists of four levels:

1. The level of logical controllers, which implements direct control of the equipment and receives data from sensors. This level consists of programmable

logical controllers, the communication of which with the higher level occurs according to standardized protocols.

2. The system level, which implements PLC control as a single system. This level consists of server equipment, which is responsible for processing and storing information. In this case, the implementation of hardware servers can be both local and remote.

3. The main server, which combines system-level servers and ensures their operation as a single automated complex.

4. Automated workstations, which provide system operators with access to permitted functions.

2. Production system architecture. Production systems are divided into two types, which implements their vertical distribution:

1. Production systems of the system level, which implement a three-level architecture. The lower level implements direct control of field-level equipment, the component level combines equipment into logical components, the system level performs equipment interaction and implements system operation algorithms. Production systems of this level are installed on computing servers of individual systems, which implements their horizontal distribution.

2. Production systems of the main server level, which implement a two-level architecture. The component level performs direct control of each individual system of the complex, and the system level combines all systems of the control object into a single automated complex.

Each production system consists of distributed working memory and knowledge base, as well as a logical inference mechanism, which implements work from the lower to the upper level of the hierarchy.

3. Computational experiments. The presented approach to the implementation of a hierarchical object was tested on a complex system consisting of emergency lighting system, emergency power supply and access control and management system of a data center. CLIPS [5] was chosen as a production model.

6 sets of emergency scenarios were defined for testing the software and hardware complex:

1. Failure of a non-critical component of one of the systems.
2. Failure of 10% of the components of one of the systems.
3. Failure of a critical component of one of the systems.
4. Failure of 10% of the critical components of one of the systems.
5. Conflict in the operation of components of one system.
6. Intersystem conflicts.

The main parameters considered during the testing process were the correctness of decision-making by the distributed production system, information processing time, and the proportion of fully automated control actions. The presented method was compared with the traditional control method implemented on a finite state machine. The results showed that the proposed method is 10% slower, but has 16% higher correctness and increases the share of fully automated actions by 15%.

Conclusions: 1. A four-level architecture of the IDCS is defined, which allows to implement the functioning of complex hierarchical automation objects.

2. The architecture of a three-level production system for the system level of automation is presented, and a two-level architecture of a production system for automated control at the main server level is presented.

3. The presented models are tested on the IDCS test problem with three systems. The advantages of the proposed method over the finite state machine method are determined: an increase in correctness by 16% and an increase in the share of fully automated actions by 15%.

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КЕРУВАННЯ ІЄРАРХІЧНИМ ОБ’ЄКТОМ НА ОСНОВІ ПРОДУКЦІЙНОЇ МОДЕЛІ

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Анотація. *Через ускладнення архітектури та алгоритмів роботи автоматизованих систем диспетчерського управління (АСДУ) загальноприйняті методи керування не дозволяють гарантувати абсолютну коректність та достатню швидкість функціонування об’єкту автоматизації. Тому розробка методів з покращення цих показників є актуальною задачею та має практичне значення. Метою роботи є представлення методу автоматизованого керування динамічною АСДУ на основі продукційної моделі. Висновки: 1) визначено чотирирівневу архітектуру АСДУ, яка дозволяє реалізовувати функціонування складних ієрархічних об'єктів автоматизації; 2) представлено архітектуру трирівневої продукційної системи для системного рівня автоматизації, та дворівневу архітектуру продукційної системи для автоматизованого керування на рівні головного серверу; 3) виконано апробацію запропонованого методу та визначено його переваги над загальноприйнятим методом скінченного автомату: підвищення коректності на 16% і збільшення частки повністю автоматизованих дій на 15%.*

Ключові слова: *продукційна модель представлення знань, автоматизована система диспетчерського управління, логічне виведення, CLIPS.*

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