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TENSOR APPROACH TO DESIGN AND STUDY OF COMPLEX SYSTEMS

Аннотация: Применение параллельных вычислительных систем является стратегическим направлением развития вычислительной техники. Это обстоятельство вызвано не только принципиальным ограничением максимально возможного быстродействия обычных последовательных ЭВМ, но и тем, что растет количество вычислительных задач, для решения которых возможностей существующих средств вычислительной техники оказывается недостаточно. Тензорной подход к исследованию моделей, построенных в терминах сетей Петри, даст возможность декомпозиции СП-моделей сложных систем и синтеза новых структур.

Ключевые слова: тензорный подход, сети Петри, сложная система, параллельные вычислительные системы, проектирование.

Abstract: The use of parallel computing systems is a strategic direction in the development of computer technology. This circumstance is caused not only by the fundamental limitation of the maximum possible speed of conventional serial computers, but also by the fact that the number of computational tasks is growing, for which the capabilities of existing computer technology are not enough. The tensor approach to the study of models built in terms of Petri nets will make it possible to decompose SP models of complex systems and synthesize new structures.

Keywords: tensor approach, Petri nets, complex system, parallel computing systems, design.

Among the many models focused on solving various problems of modeling, analysis and synthesis of processes of various nature (including computational processes and control processes), the so-called Petri nets receive great attention. Researchers are attracted by such advantages of Petri nets as the ability to represent the dynamics of the functioning of processes, reflect the properties of non-determinism, asynchrony and parallelism of processes, simplicity of syntax and visibility of the model.

To study the modeling ability (more precisely, the functionality) of Petri nets and compare the capabilities of Petri nets with the capabilities of other objects known in the theory of automata (Turing machines, finite automata, etc.), Petri nets are interpreted [3].

The analysis of a specific Petri net is understood as a set of methods, algorithms and techniques used to study its static (structural) and dynamic (behavioral) properties. During the analysis, the presence of some of its positive properties or anomalies characterizing the undesirable effects of behavior is established [1]. The interpretation of certain properties as positive or negative depends on the semantics of the process modeled by the Petri net.

The use of parallel computing systems is a strategic direction in the development of computer technology. This circumstance is caused not only by the fundamental limitation of the maximum possible speed of conventional serial computers, but also by the fact that the number of computational tasks is growing, for which the capabilities of existing computer technology are not enough. Sequential systems do not allow building promising real-time processing systems and it is necessary to attract additional capacities in the form of parallel computing structures [2]. Therefore, complex systems are becoming the main object of study of modern science.

By a complex computing system, we mean such a computing system, the law of operation of which allows decomposition into separate components. The structure of a complex computing system is understood as the organization of a system from individual elements, for which the method of interconnection with the environment is indicated, as well as the distribution of functions performed by the system. The features of such systems are parallelism, non-determinism, the presence of interacting processes, a combination of synchronous and asynchronous control, etc.

The contradictions that arise between the complexity of modern systems being created and traditional approaches to their design determine one of the main tasks of systems theory - the development of effective structures for complex systems.

Modern methods used in the analysis and synthesis of structures of complex systems are based on methods of decomposition, coordination, aggregation, structural approach, an approach based on complexity theory, etc. To successfully solve the problem of analysis and synthesis of increasingly complex systems, further development and improvement is required. mathematical methods of their research. It is necessary to develop methods and algorithms that make it possible to conduct a directed search for the optimal characteristics of the system and to control changes in these characteristics during the design process. All of the above has led to the development of a systematic approach to the design of complex systems, i.e. integrated consideration and representation in the system of both objects and design operations at various stages of the design process [3; 4].

Positive properties of the system approach for designing structures of computing systems:

1. A structural approach to the design and construction of alternative options based on a generalized model allows the designer to obtain the entire set of possible options from which the optimal structures are selected.

2. Due to the increasing complexity of the designed structures of computing systems, decomposition and aggregation methods provide ample opportunities, which allow the analysis and synthesis of models in parts

3. The possibility of studying subsystems of complex computing systems, presented in varying degrees of detail, which makes it possible to reduce the

dimension of the general model of computing systems and conduct research using PCs that are widely available to users.

4. Ease of getting alternatives.

The approach to designing complex computing systems based on tensor methods has all these properties. For more efficient use of this approach, description tools are needed that can reflect the parallel development of processes [5; 6]. Petri nets, which describe the structure and interaction of parallel processes, can become such a tool.

The subsequent analysis of Petri nets allows you to obtain the most important information about the structure of the simulated system and its dynamic behavior, and then use this data to evaluate the simulated system and develop proposals for its improvement. The tensor approach to the study of models built in terms of Petri nets (SP-models) gives us the possibility of decomposition of SP-models of complex systems and the synthesis of new structures.

Using the possibilities of structural analysis of complex systems, and in particular SP-models, allows you to set a system of evaluation scales on a set of constructed models and analyze the properties of the constructed models. It is required, on the basis of predetermined requirements, to formulate a set of rules that will limit the set of SP models, and as a result of the analysis, it will be possible to select only those structures that meet these requirements.

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