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MODELS OF OPTIMAL REDUCTION IN DECOMPOSITION PROBLEMS SOLUTION AND STRUCTURES MODELLING

In this article optimal reduction models are presented. Peculiarities of their use in the process of decomposition tasks and complex system modelling are described.The influence of tht problem model on the designing result is analysed.

Key words: model , decomposition, reduction, tree, acyclic digraph.

Розглянуто моделі оптимальної редукції і особливості їх використання під час розв'язання низки декомпозиційних задач і моделювання складних систем. Проаналізовано вплив моделі задачі на результат проектування.

Ключові слова: модель , декомпозиція, редукція, дерево, безконтурний орграф.

Introduction

At each level of complex objects and systems design there is a lot of decomposition tasks. Among them could be named the following: structural decomposition and functional decomposition (typing and coverage), the minimum decomposition result in the given conditions etc. In the process of such problems class solution widely used besides the multiple models are the models of different graphs and networks types, such as simple graphs, multigraphs, hypergraph and bipartite graphs. Among the effective solution algorithms of decomposition problems are consecutive (for the process of synthesis tasks solution) and iterative (for the process of the obtained solutions optimization). Separately could be named algorithms of optimal reduction with computational complexity of the basic procedures within $O(n^3)$, where n is the dimension of the problem not requiring further optimization and solves all the complex of decomposition tasks [1].

Reduction binary trees may be applied in the modelling process when projecting technical, program systems and databases.

Models of complex objects and systems structures

There are seven the most commonly used discrete models of complex objects and systems representations:

1. Set
2. Graphs
3. Multigraphs
4. Nets
5. Directed graphs
6. Bipartite graphs
7. Hypergraphs

Priority is given to *multigraphs* and *nets*, considering ease presentation in the form of square symmetric matrix, which enables fast algorithms of processing.

Classes of the decomposition problems and methods of their solution

The main types of decomposition problems could be divided into the following:

1). Structural Decomposition:

• Minimizing the number of interconnects (the number of edges in the graph model section);
• Minimizing the number of parts of partitions (pieces of graph models).

2). Functional decomposition:

• Typing (searching in the graph isomorphic subgraphs).

• Covering (searching in graph isomorphic to given subgraphs).

The methods of decomposition problems solution could be divided into the following:

• *Accurate methods* (branch and bound, exhaustive search method) with exponential complexity

• *Approximate methods* (sequential, iterative, parallel-sequential) with polynomial complexity.

In the modern designing systems widely used are the following methods:

• *Consecutive* (synthesis)

• *Iterative, permutations* (optimization).

• *Optimal reduction and decomposition based on it* (synthesis).

Optimal reduction and binary trees of the basic reduction procedure and theirs using in problems of decomposition

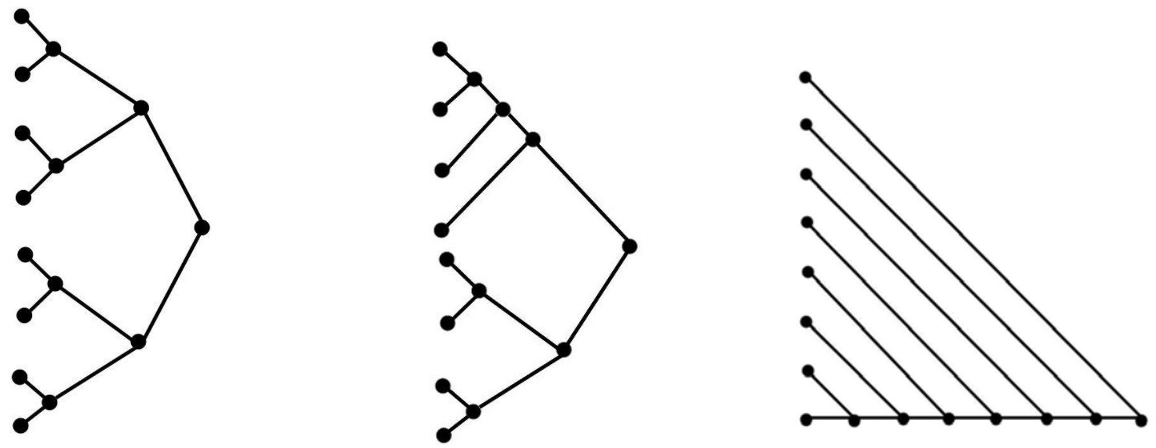
The result of the sequential algorithms work do not always meet the needs of developer. Iterative algorithms have low productivity. These shortcomings can be rid of by using the method of optimal reduction [2].

Physical counterpart of the optimal reduction is the crystallization process. Model of the process of reduction is ordered binary tree.

The process of reduction of the structure model can be done in parallel, parallel-serial, sequential computational complexity of this procedure ranges from O (n^2) for the parallel case and O (n^3) for the serial case. Reducing the number of steps L:

$$log_2 n \le L \le n-1$$

Possible variants of the basic structure model, where n – number of vertices in the basic graph model, are depicted in the fig.1.



a). Parallel reduction   b). Parallel –sequential reduction   c). Sequential reduction

Fig. 1. Possible variants of basic model reduction

Dangling vertices of trees correspond to basic model vertices, intermediate vertices correspond to subgraphs, that are created in the process of reduction, head vertex correspond to basic model in general.

The most successful reduction model in the process of solving a wide class of decomposition tasks are reduction binary trees. On the basis of such trees use the task of decomposition may be reduced to the analysis and the cutting of the most simple graph model which they are [3]. It concerns also the solutions of a number of related problems in graphs, for example, ascertainment of the graphs isomorphism and selection in the graph of the isomorphic subgraphs[4].

The optimality criteria of intermediate vertices creation in the process of reduction are the following:

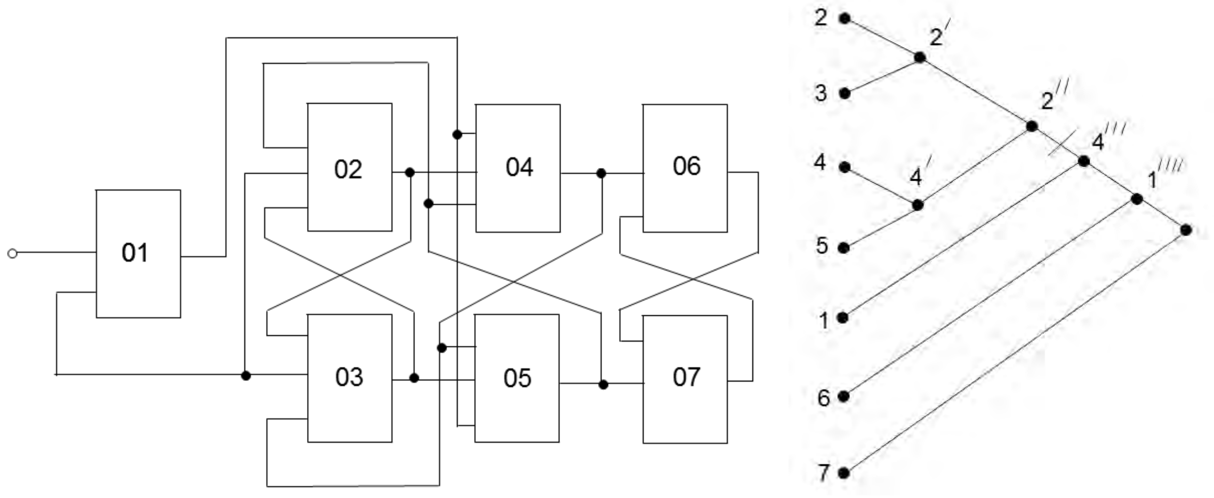
1). Structure decomposition:

- Maximum connectivity of elements which are forming a new pair.

2). Functional decomposition:

- One step of reduction unites couples with the same value type of specified parameters.

For example, the fragment of digital device scheme and the reduction tree is presented in the fig.2.



a *b*

$X_1=\{x_2, x_3, x_4, x_5\}$

$X_2=\{x_1, x_6, x_7\}$

Fig. 2. Fragment of digital device scheme and its he reduction tree:
a – scheme fragment; b – binary tree of reduction and the result of division into two parts

Minimizing the number of partitioning subcircuits. Acyclic digraph.

The minimization of decomposition components number is an important issue of the projected object structure decomposition. None of the existing methods of decomposition is aimed at obtaining a appropriate result. The use of optimal reduction model in the form of a binary tree solves the problem. For example, a package of programs [5] has reduced the number of blocks from eleven to eight compared to the program of consecutive algorithm. The solution of the problem by Rousseau [6], who was opposed to the algorithmic solution, because it requires duplication of scheme elements is also interesting. Optimal reduction allows solving this problem in the process of transition from the model in the form of a binary tree to the model of the acyclic digraph. Russo problem and the results are presented in fig. 3.

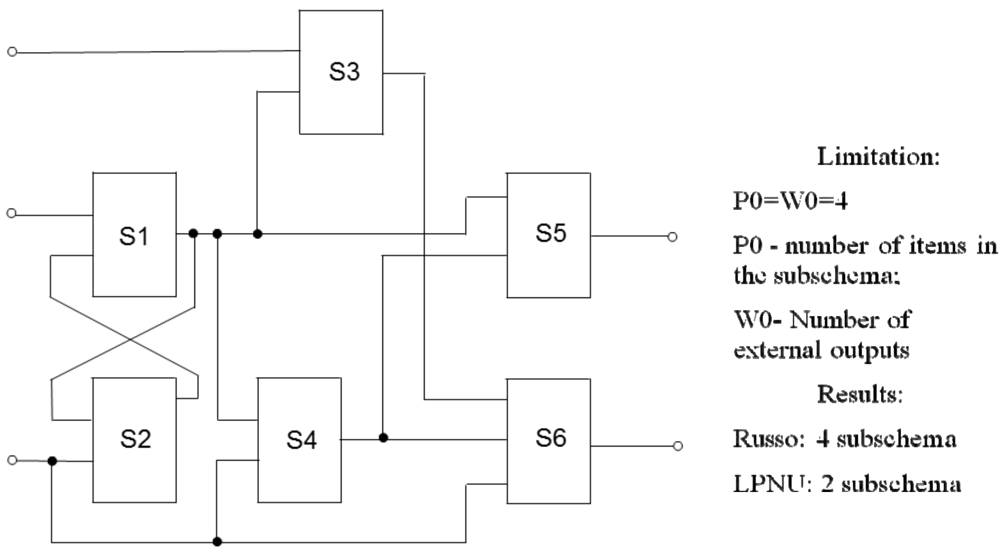


Fig. 3. Russo problem

Acyclic digraph, which presents the solution of Russo problem by using the optimal reduction on the hypergraph model is depicted in the fig.4.

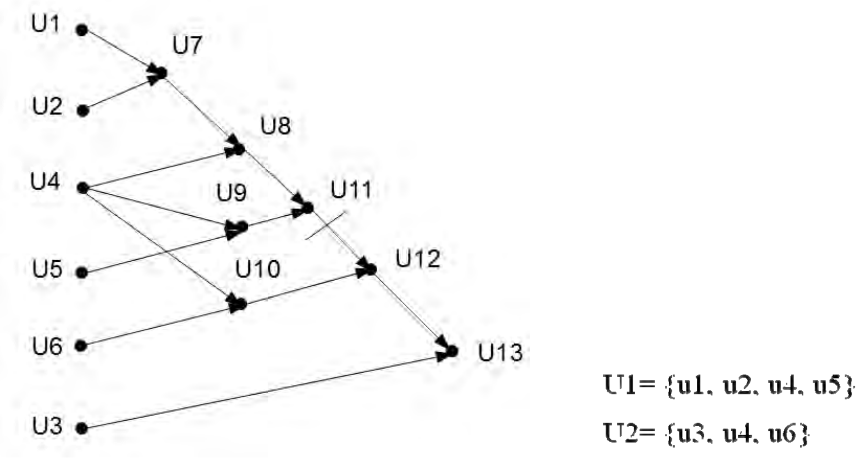


Fig. 4. Acyclic digraph, obtained in the result of the optimal reduction used on hypergraph model

Conclusion

The use of optimal reduction method allows solving a wide range of decomposition tasks, including minimization of decomposition components and functional decomposition. But it may result in the necessity to use weight functions on the vertices and edges (arcs) of reduction binary trees and more precise basic models such as hypergfaph.

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