Parallel Algorithm and Functional Organization of the Restoration Environment in Multiprocessor's Logical Structure

A.V. Malyshev

Department of Software Engineering, South-West State University, Kursk, Russia,
e-mail: alta76@yandex.ru

Abstract - The author proposes a parallel algorithm for reconfiguration of the multiprocessor's logical structure using central column of the reserve elements and which allows building recovery paths from matrix's faulty nodes with the virtual channels of their programming modules in comprehensible time for systems of high readiness.

Keyword - Multiprocessor, fault-tolerance, reconfiguration

I. INTRODUCTION

One of main types of the organization of the distributed systems is mesh architecture [1]. In this article the multiprocessor intended for parallel processing of the information with array structure which advantages are considered:

a high regularity level - i.e. each processor element (PE), except for last ones, is connected to four adjacent;

homogeneity - i.e. structure of all PE is identical.

Thus, for support of fail safety, reserve modules are entered into this multiprocessor in addition. In case of failure of the main nodes, changeover of the refused PE is carried out by reconfiguration.

II. TASK DEFINITION

For the purpose of solution reproduction task in a logical structure of the multiprocessor we will interpret a set of PE, which amount superfluous than required by parallel algorithm. For status description of the considered resources of multiprocessor we will enter graph models [2], for which:

- the set of nodes of a matrix includes the peaks corresponding to the operable, refused and reserve elements;
- location of peaks in space is set by their integer coordinates in two-dimensional space;
- adjacent peaks of a matrix connected by the edges located in the directions set for this structure and have no multiple communications and loops;
- the distance between pairs of adjacent peaks in a grid is constant for the given direction of arcs orientation.

During reconfiguration there is a change of the virtual addresses (VA) of a graph nodes structure of the multiprocessor. It, leads to realignment of part of peaks on other private algorithms. Realignment of peak on other private algorithm requires that the context of this private algorithm corresponded to a context of that its copy on which one of peaks before appearance of failures was set up.

To provide compliance it is necessary to change similarly in case of change of a one copy context of private algorithm a context and remaining copies. It shall be reached by transmission of the synchronizing messages on VA of peaks receivers.

III. ALGORITHM OF FUNCTIONING

As a layer of reproduction of the multiprocessor we will accept a matrix from $n \times m$ elements. Each cell of this layer sets up PE corresponding to it with a physical address (PA) (*i*,*j*) on one of functioning algorithms: characteristic (*i*,*j*), top (*i*+1,*j*), lower (*i*-1,*j*), right (*i*,*j*+1), left (*i*,*j*-1) depending on failures or change of functioning algorithms top (*i*+1,*j*)-го, lower (*i*-1,*j*)-го, right (*i*,*j*+1)-го and left (*i*,*j*-1) PE.

Functioning algorithm (*i'*,*j'*), on which it is set up (*i*, *j*) cell, there will match VA (*i*, *j*) cells. Firstly all PE except reserved, have VA equal PA. As the reserve we will take PE]m/2[-column (where][- round upwards), which originally have BA=(0,0), i.e. don't execute any algorithm functioning.

In case of PE rejections the set of interacting layer cells of reproduction recustomizes operable PE (including the reserve) for new VA. Thus, cells interaction are carried out by signals

$$X_1^{ij} = \{x_{11}, x_{12}, x_{13}, x_{14}\}, X_2^{ij} = \{x_{21}, x_{22}, x_{23}, x_{24}\}$$

potential and real relocation, respectively, arriving from (*i*, *j*) cells of a homogeneous environment to physical neighbors. Potential relocation signals from (*i*, *j*) cells inform adjacent cells on possibility of realignment (*i*,*j*) PE on one of the appropriate functioning algorithms, and the signal of real relocation from the same cell informs one of neighboring nodes on its realignment to (*i*, *j*) algorithm.

In the failures absence framing of signals of potential relocation is initiated by reserve elements in all directions. In case of rejection of PE framing of signals of potential relocation from them stops, and each refused module initiates a signal of real relocation in one of 4 directions, since the priority. It is worth marking that operable PE initiate signals of real relocation only in case of arrival of such signal from neighbors, and reserve don't initiate them at all.

In case of arrival in one PE of two and more signals of real relocation there is a conflict situation, since each PE can execute only one functioning. The conflict situation is resolved by blocking output signals of potential relocation in the arrival direction of less priority signals of real relocation. In case of this PE, the working-out these signals of real relocation, work out them and in other directions. Priority of the directions for PE located to the left of a reserve element: to the right, up, down, to the left. For PE located on the right: to the left, up, down, to the right. If any signal doesn't come to the refused PE of potential relocation, there is a situation of a fatal failure, i.e. realignment is impossible.

We will write algorithm of reproduction in the form of several groups of the systems of parallel substitutions (SPS), having entered the following designations:

x_0^{ij} - working capacity or rejection of a node of a matrix;

x_r^{ij} - reserve or main node of a matrix;

x_{11}^{ij} - node accessibility at the left;

x_{12}^{ij} - node accessibility from below;

x_{13}^{ij} - node accessibility from top;

x_{14}^{ij} - node accessibility at the right;

x_n^{ij} - node belonging to the left (x_n^{ij}=1), or to the right (x_n^{ij}=0) to areas of a matrix of rather reserve column;

x_{21}^{ij} - transfer of the program to the right;

x_{22}^{ij} - transfer of the program to the top;

x_{23}^{ij} - transfer of the program down;

x_{24}^{ij} - transfer of the program to the left;

A_k^{ij} - the prohibition of reception the messages with direction *k* (Fig. 1).

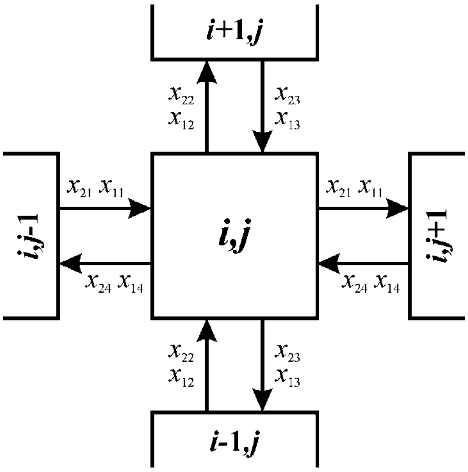

Fig. 1. Numbering of the directions of signal transmission of accessibility in a matrix of the multiprocessor elements

SPS for formation operation of the reception prohibition:

$$\begin{cases} (x_{21}^{i,j-1} * x_{22}^{i+1,j}) * x_n^{ij} \rightarrow A_1^{ij}, \\ A_1^{ij} = x_{21}^{i,j-1} \cdot x_{22}^{i+1,j}, \\ (x_{21}^{i,j-1} * x_{23}^{i-1,j}) * x_n^{ij} \rightarrow A_1^{ij}, \\ A_1^{ij} = x_{21}^{i,j-1} \cdot x_{23}^{i-1,j}, \\ (x_{22}^{i+1,j} * x_{23}^{i-1,j}) * x_n^{ij} \rightarrow A_1^{ij}, \\ A_1^{ij} = x_{22}^{i+1,j} \cdot x_{23}^{i-1,j}. \end{cases} \quad (1)$$

$$\begin{cases} (x_{22}^{i+1,j} * x_{23}^{i-1,j}) * \overline{x}_n^{ij} \rightarrow A_4^{ij}, \\ A_4^{ij} = x_{22}^{i+1,j} \cdot x_{23}^{i-1,j}, \\ (x_{22}^{i+1,j} * x_{24}^{i,j+1}) * \overline{x}_n^{ij} \rightarrow A_4^{ij}, \\ A_4^{ij} = x_{22}^{i+1,j} \cdot x_{24}^{i,j+1}, \\ (x_{23}^{i-1,j} * x_{24}^{i,j+1}) * \overline{x}_n^{ij} \rightarrow A_4^{ij}, \\ A_4^{ij} = x_{23}^{i-1,j} \cdot x_{24}^{i,j+1}. \end{cases} \quad (2)$$

SPS for formation operation of signals for accessibility:

$$\begin{cases} (x_{11}^{ij} * x_n^{ij}) * \overline{A}_1^{ij} * \overline{x}_0^{ij} \rightarrow f_{11}^{ij}, \\ f_{11}^{ij} = x_n^{ij} \cdot x_{11}^{i,j-1}, \\ (x_{12}^{ij} * x_n^{ij}) * \overline{A}_1^{ij} * \overline{x}_0^{ij} \rightarrow f_{11}^{ij}, \\ f_{11}^{ij} = x_n^{ij} \cdot x_{12}^{i+1,j}, \\ (x_{13}^{ij} * x_n^{ij}) * \overline{A}_1^{ij} * \overline{x}_0^{ij} \rightarrow f_{11}^{ij}, \\ f_{11}^{ij} = x_n^{ij} \cdot x_{13}^{i-1,j}, \\ (x_r^{ij}) * \overline{A}_1^{ij} * \overline{x}_0^{ij} \rightarrow f_{11}^{ij}, \\ f_{11}^{ij} = x_f^{ij}. \end{cases} \quad (3)$$

$$\begin{cases} (x_{11}^{ij}) * \overline{x}_0^{ij} \to f_{12}^{ij}, \\ f_{12}^{ij} = x_{11}^{i,j-1}, \\ (x_{12}^{ij}) * \overline{x}_0^{ij} \to f_{12}^{ij}, \\ f_{12}^{ij} = x_{12}^{i+1,j}, \\ (x_{13}^{ij}) * \overline{x}_0^{ij} \to f_{12}^{ij}, \\ f_{12}^{ij} = x_{13}^{i-1,j}, \\ (x_{14}^{ij}) * \overline{x}_0^{ij} \to f_{12}^{ij}, \\ f_{12}^{ij} = x_{11}^{i,j+1}, \\ (x_r^{ij}) * \overline{x}_0^{ij} \to f_{12}^{ij}, \\ f_{12}^{ij} = x_r^{ij}. \end{cases} \quad (4)$$

$$\begin{cases} (x_{11}^{ij}) * \overline{x}_0^{ij} \to f_{13}^{ij}, \\ f_{13}^{ij} = x_{11}^{i,j-1}, \\ (x_{12}^{ij}) * \overline{x}_0^{ij} \to f_{13}^{ij}, \\ f_{13}^{ij} = x_{12}^{i+1,j}, \\ (x_{13}^{ij}) * \overline{x}_0^{ij} \to f_{13}^{ij}, \\ f_{13}^{ij} = x_{13}^{i-1,j}, \\ (x_{14}^{ij}) * \overline{x}_0^{ij} \to f_{13}^{ij}, \\ f_{13}^{ij} = x_{14}^{i,j+1}, \\ (x_r^{ij}) * \overline{x}_0^{ij} \to f_{13}^{ij}, \\ f_{13}^{ij} = x_r^{ij}. \end{cases} \quad (5)$$

$$\begin{cases} (x_{12}^{ij} * \overline{x}_n^{ij}) * \overline{A}_4^{ij} * \overline{x}_0^{ij} \to f_{14}^{ij}, \\ f_{14}^{ij} = \overline{x}_n^{ij} \cdot x_{12}^{i+1,j}, \\ (x_{13}^{ij} * \overline{x}_n^{ij}) * \overline{A}_4^{ij} * \overline{x}_0^{ij} \to f_{14}^{ij}, \\ f_{14}^{ij} = \overline{x}_n^{ij} \cdot x_{13}^{i-1,j}, \\ (x_{14}^{ij} * \overline{x}_n^{ij}) * \overline{A}_4^{ij} * \overline{x}_0^{ij} \to f_{14}^{ij}, \\ f_{14}^{ij} = \overline{x}_n^{ij} \cdot x_{14}^{i,j+1}, \\ (x_r^{ij}) * \overline{A}_4^{ij} * \overline{x}_0^{ij} \to f_{14}^{ij}, \\ f_{14}^{ij} = x_f^{ij}. \end{cases} \quad (6)$$

SPS for formation operation of transferring program:

$$\begin{cases} (x_{21}^{i,j-1}) * x_{11}^{ij} * \overline{x}_r^{ij} \to \gamma_{21}^{ij}, \\ \gamma_{21}^{ij} = x_{21}^{i,j-1}, \\ (x_{22}^{i+1,j}) * x_{11}^{ij} * \overline{x}_r^{ij} \to \gamma_{21}^{ij}, \\ \gamma_{21}^{ij} = x_{22}^{i+1,j}, \\ (x_{23}^{i-1,j}) * x_{11}^{ij} * \overline{x}_r^{ij} \to \gamma_{21}^{ij}, \\ \gamma_{21}^{ij} = x_{23}^{i-1,j}, \\ (x_0^{ij}) * x_{11}^{ij} * \overline{x}_r^{ij} \to \gamma_{21}^{ij}, \\ \gamma_{21}^{ij} = x_0^{ij}. \end{cases} \quad (7)$$

$$\begin{cases} (x_{21}^{i,j-1} * \overline{x}_{11}^{ij}) * x_{12}^{ij} * \overline{x}_r^{ij} \to \gamma_{22}^{ij}, \\ \gamma_{22}^{ij} = x_{21}^{i,j-1} \cdot \overline{x}_{11}^{i,j-1}, \\ (x_{22}^{i+1,j} * \overline{x}_{11}^{ij}) * x_{12}^{ij} * \overline{x}_r^{ij} \to \gamma_{22}^{ij}, \\ \gamma_{22}^{ij} = x_{22}^{i+1,j} \cdot \overline{x}_{11}^{i,j-1}, \\ (x_{22}^{i+1,j} * \overline{x}_{14}^{ij}) * x_{12}^{ij} * \overline{x}_r^{ij} \to \gamma_{22}^{ij}, \\ \gamma_{21}^{ij} = x_{22}^{i+1,j} \cdot \overline{x}_{14}^{i,j+1}, \\ (x_{23}^{i-1,j} * \overline{x}_{11}^{ij}) * x_{12}^{ij} * \overline{x}_r^{ij} \to \gamma_{22}^{ij}, \\ \gamma_{22}^{ij} = x_{23}^{i-1,j} \cdot \overline{x}_{11}^{i,j-1}, \\ (x_{23}^{i-1,j} * \overline{x}_{14}^{ij}) * x_{12}^{ij} * \overline{x}_r^{ij} \to \gamma_{22}^{ij}, \\ \gamma_{22}^{ij} = x_{23}^{i-1,j} \cdot \overline{x}_{14}^{i,j+1}, \\ (x_{24}^{i,j+1} * \overline{x}_{14}^{ij}) * x_{12}^{ij} * \overline{x}_r^{ij} \to \gamma_{22}^{ij}, \\ \gamma_{22}^{ij} = x_{24}^{i,j+1} \cdot \overline{x}_{14}^{i,j+1}, \\ (x_0^{ij} * \overline{x}_{11}^{ij}) * x_{12}^{ij} * \overline{x}_r^{ij} \to \gamma_{21}^{ij}, \\ \gamma_{21}^{ij} = x_0^{ij} \cdot * \overline{x}_{11}^{ij}. \end{cases} \quad (8)$$

$$\begin{cases} (x_{21}^{i,j-1} * \overline{x}_{11}^{ij}) * x_{12}^{ij} * \overline{x}_r^{ij} \rightarrow \gamma_{23}^{ij}, \\ \gamma_{23}^{ij} = x_{21}^{i,j-1} \cdot \overline{x}_{11}^{i,j-1}, \\ (x_{22}^{i+1,j} * \overline{x}_{11}^{ij}) * x_{12}^{ij} * \overline{x}_r^{ij} \rightarrow \gamma_{23}^{ij}, \\ \gamma_{23}^{ij} = x_{22}^{i+1,j} \cdot \overline{x}_{11}^{i,j-1}, \\ (x_{22}^{i+1,j} * \overline{x}_{14}^{ij}) * x_{12}^{ij} * \overline{x}_r^{ij} \rightarrow \gamma_{23}^{ij}, \\ \gamma_{23}^{ij} = x_{22}^{i+1,j} \cdot \overline{x}_{14}^{i,j+1}, \\ (x_{23}^{i-1,j} * \overline{x}_{11}^{ij}) * x_{12}^{ij} * \overline{x}_r^{ij} \rightarrow \gamma_{23}^{ij}, \\ \gamma_{23}^{ij} = x_{23}^{i-1,j} \cdot \overline{x}_{11}^{i,j-1}, \\ (x_{23}^{i-1,j} * \overline{x}_{14}^{ij}) * x_{12}^{ij} * \overline{x}_r^{ij} \rightarrow \gamma_{23}^{ij}, \\ \gamma_{23}^{ij} = x_{23}^{i-1,j} \cdot \overline{x}_{14}^{i,j+1}, \\ (x_{24}^{i,j+1} * \overline{x}_{14}^{ij}) * x_{12}^{ij} * \overline{x}_r^{ij} \rightarrow \gamma_{23}^{ij}, \\ \gamma_{23}^{ij} = x_{24}^{i,j+1} \cdot \overline{x}_{14}^{i,j+1}, \\ (x_0^{ij} * \overline{x}_{11}^{ij}) * x_{12}^{ij} * \overline{x}_r^{ij} \rightarrow \gamma_{23}^{ij}, \\ \gamma_{23}^{ij} = x_0^{ij} \cdot * \overline{x}_{11}^{ij}. \end{cases} \quad (9)$$

$$\begin{cases} (x_{22}^{i+1,j}) * x_{14}^{ij} * \overline{x}_r^{ij} \rightarrow \gamma_{24}^{ij}, \\ \gamma_{24}^{ij} = x_{21}^{i+1,j}, \\ (x_{23}^{i-1,j}) * x_{14}^{ij} * \overline{x}_r^{ij} \rightarrow \gamma_{24}^{ij}, \\ \gamma_{24}^{ij} = x_{23}^{i-1,j}, \\ (x_{24}^{i+1,j}) * x_{14}^{ij} * \overline{x}_r^{ij} \rightarrow \gamma_{24}^{ij}, \\ \gamma_{24}^{ij} = x_{24}^{i+1,j}, \\ (x_0^{ij}) * x_{14}^{ij} * \overline{x}_r^{ij} \rightarrow \gamma_{24}^{ij}, \\ \gamma_{24}^{ij} = x_0^{ij}. \end{cases} \quad (10)$$

As an example we will consider the conflict situation given on Fig. 2, where:

- thin arrows designated signals of potential relocation;
- bold - real;
- $X_л$ - left part of the multiprocessor;
- X_n - right part of the multiprocessor;
- X_r - reserve column.

In this case the priority in case of reproduction is given to the refused elements located in the left part of a matrix since a signal $x_{14}^{i,j+1}$, according to the functional diagram of a cell of a layer of reconfiguration [3], accepts value of logical unit, and $x_{11}^{i,j-1}$ - logical zero. Thus, the cell of the refused element located at the left will receive the single signal of potential relocation allowing redistribution to the right.

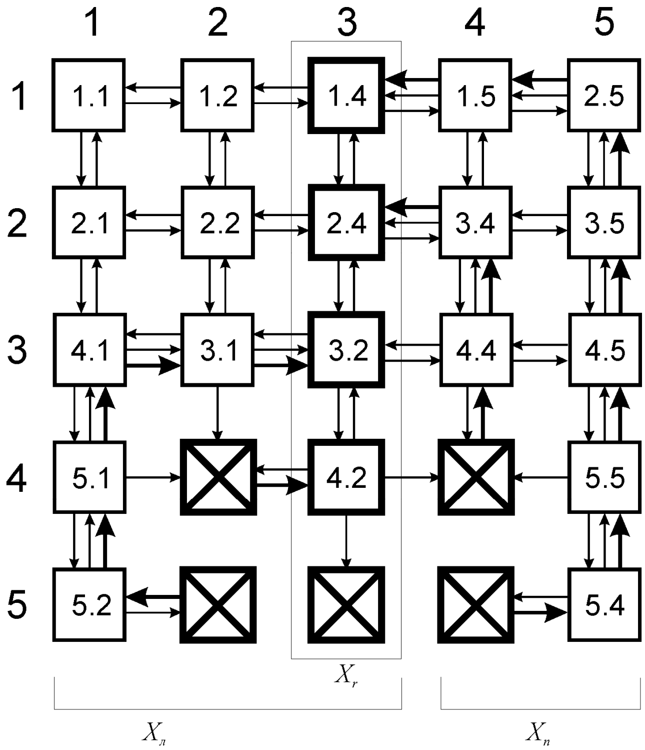

Fig. 2. The diagram of signals distribution in the presence of rejections

IV. CONCLUSION

The provided parallel algorithm of reconfiguration of the multiprocessor with flexible placement of a column of reserve elements based on interaction of cells of the environment of reproduction by means of signals of potential and real relocation, allows to make restoration of its logical structure during the time accepted for systems of high readiness.

REFERENCES

[1] A.V. Malyshev and D.A. Monday. "Self-Reconfigurable Architecture and Algorithm of Reconstruction for Multicontrollers," in Proc. MPZIS'08, 2008, pp. 214-215.

[2] A.V. Malyshev. "Reconfiguration algorithm of symbolical multiprocessor's logical structure," in Proc. "Interactive Systems and Technologies", 2011, pp. 295-297.

[3] A.V. Malyshev, M.V. Medvedeva and V.A. Koloskov. "Search of a Subscriber in a Reproduced-Behavior Program Multicontroller," Telecommunications and Radio Engineering, vol. 62, pp. 343-354, 2004.