3D FRAME MODELS SWITCHING ELEMENTS BY BEREZOVSKY FOR SOFTWARE-CONFIGURABLE SWITCHING STRUCTURES

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Abstract. The frame 2D and 3D models of patented by Berezovsky switching elements are proposed in relation to the construction of topologies of switching structures admissible for reconfiguration. It has been revealed that the use of frame models by Berezovsky switching elements allows to visualize the information about the state of the structure of switching elements, to vary the number of independent inputs and outputs, and provides additional possibilities in the simulation of topologies of modern structures with separated by planes data and control. The method of formation of states of the switching structure topology elements has been proposed.

Keywords: switching elements by Berezovsky, model of switching elements by Berezovsky, 3D switching structures on the elements by Berezovsky.

INTRODUCTION

The Fourth Industrial Revolution (4IR) is a new era in the development of mankind, characterized by the “blurring” the boundaries between the real world and digital technologies.

The fundamental part of the 4IR architecture is the digital economy and the integration of smart plants into industrial infrastructures.

One of the main tasks of the 4IR is the definition of common platforms of “service-oriented design” with a single information language space in which machines of different corporations will freely communicate.

A completely new type of industrial production, based on the so-called Big Data and their analysis, complete automation of production, augmented reality technologies, the Internet of things is emerging.

This means a wave of discoveries caused by the development of the possibilities of self-adjusting telecommunication architectures capable of adapting to new realities (needs) in a completely autonomous mode without human participation.

Cloud technologies, the development of collecting and analyzing methods for Big Data, secure and protected “smart network” technologies, intelligent switching systems and structures in the field of data transmission have become the key technologies of the new industrial revolution [1].
NEW SOFTWARE-DEFINED SWITCHING ARCHITECTURE

Traditionally, the main infrastructures nodes of Software Defined Switching Structures, Systems and Networks (SDSSSN) appear for customers in the form of some “black boxes”: proprietary equipment, proprietary network operating system, hardwired by manufacturer set of functions and a specific utility for managing this entire pack.

The company Cisco is leading among the developers in this field, offering a platform that uses a unified switching matrix. However, the installation of newer and newer hardware devices, which configuration varies for each customer, leads to a multiple increase of the load i.e. the amount of service information sufficient to slightly get confused in new and specific data related to the basic computer control devices of the SDSSSN, not always clearly structured.

The construction components of the SDSSSN offered by the suppliers to the suppliers are still 2D component file structures, which dominate in the technology nowadays as well.

Topology was based on the use of the simplest integration mechanisms of individual components and was limited to the level of technology development, the implementation of elementary 2D models based on the interface of minimal user interaction with ECM [2]. This determined in many ways the capabilities of the SDSSSN designers.

In the new initiative SDSSSN construction two stages have been distinguished, in the first stage the existing monolithic approach is divided into hardware and software parts, the second one assumes a completely modular approach where all components can be isolated and replaced with suitable ones.

The new architecture framework

The new building element of the SDSSSN is a switching element (SE) without an operating system, a kind of SE without embedded software, but with a software boot environment providing the installation of compatible operating systems based on an open operating system (OS). This allows consumers to replace the operating system and avoid binding to the equipment supplier, and also fits into the tendency of building the SDSSSN.

As a basic generating framework, it is proposed to use Berezovsky's fully available 2D switching element (KEB-1), the graph of which is shown in Fig.1. KEB implements a set of states described by the characteristic equations [3].

The basic concept of such KEB-1 is its turn in fact into a common framework under the control of an open OS, whereas all switching functions are implemented by a special processor ("demon"), controlling the switching matrix, a field with its own driver, as one more service. In some developments, it is proposed to place the control processor on a separate daughter board, which will, in the future, even select the architecture of the processor.

The new switching element of SDSSSN must meet the most stringent requirements for continuity, flexibility and scalability, and in addition become “smarter” and faster, as a kind of “conductor” for all types of data passing through it.

2D frame models presentation of KEB-1. The need of developers and consumers in the possession of operational information on the structure, composition, state of KEB-1 predetermined the borrowing from psychology and philosophy the
known concept of an abstract image, a model for representing a certain perception stereotype.

A real need to use the physical development of SEs from different manufacturers and in the case where the physical properties of SE are not important, it is preferable to use intelligent methods of knowledge representation to describe the functions of the model as a single solution that is the frame model.

Framed models of knowledge representation are one of the most important lines of research in the field of artificial intelligence, a component of the 4IR.

The integrated complex model should provide a study of the behavior of the simulated SE in general and the influence of the constituent parts on each other, herewith it should be easily modified and expanded.

It has been suggested to use a second-order geometric figure — an ellipse as a formalized model for displaying the abstract image, in our case, the KEB frame model [3].

Frame model of KEB-1 with the number of terminals points -input-output \( n = 4 \) is shown in Fig. 2.

![Fig. 1. Graph of commutation element by Berezovsky](image1)

**Fig. 1.** Graph of commutation element by Berezovsky

**Fig. 2.** Frame model by Berezovsky

Orientation of the KEB frame model is determined by the designer proceeding from their practical convenience of representing the structure (Fig. 3).

![Fig. 3. Orientation options, KEB codes and I/O points](image2)

**Fig. 3.** Orientation options, KEB codes and I/O points

In general case, the frame data structure can contain a wide range of information, determined by the level of education, professional experience and personal maturity of both designers and consumers.

Authorial encodings of both the KEB themselves and the I/O points are possible.

**3D frame models for the presentation of KEB-2.** The emergence of new patent technologies of 3-DMS type, three-dimensional integration by means of through-silicon holes (Through Silicon Vias, TSV) will solve some problems of...
3D modern electronics, which in turn will unable solving 3D SDSSSN design issues for new communication technology, automated control systems, computer systems, robotics, unmanned aerial vehicles [4].

The N-dimensional switching element by Berezovsky KEB-2 has been synthesized [5].

The main advantage of the frame model of KEB-2 representation is that it reflects the conceptual basis by Berezovsky-2 switching element, as well as its flexibility and visibility.

The singularity of this approach is the ability to synthesize 3D models of KEB-2 for SDSSSN in a Cartesian coordinate system. The left and right variants of the rectangular 3D frame model of the KEB-2 from two generating KEB-1 in the 3-dimensional space have been proposed (Fig. 4, 5):

- 3D rectangular single frame model of KEB-2 presentation;
- 3D rectangular colored frame model of KEB-2 presentation;
- 3D rectangular frame model with KEB-2 switching state display;
- 3D rectangular colored frame model with KEB-2 switching state display.

The frame model of KEB-2 representation is offered in two varieties:

- rectangular 3D KEB-2 frame model, as a particular kind of model (Fig. 4–6);
The frame model of 3D KEB-2 is formed on the ground of basic 2D KEB-1 in the affine space of N-planes (Fig. 7) [5].

Fig. 7. Isometric frame model of the KEB-2 representation from $N = 3$ generating KEB-1 (red, blue, green) in 3-dimensional space.

Framed 3D models allow designing 3D switching matrices that can facilitate the development of options for parallel systems of collecting, processing and storing information. The KEB frame model provides an economical allocation of the knowledge base in memory, and the value of any attribute, i.e. a slot, can be calculated by appropriate procedures or found by heuristic methods.

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**SWITCHING STRUCTURES ON ELEMENTS BY BEREZOVSKY**

The 2D “flat technology” is still dominating in the world (humanity is used to and works with 2D, that is, in the plane (of a desktop) of information visualization: a diagram as a flat drawing; a picture as a flat image; chip as a plate; motherboard as a set of up to 51 layers.

Formation of the switching structure in 2D is performed according to the file principle that is by cascading entering of switching element into a line and further typing them into the page-field.

A field of $4 \times 4$ switching elements with 4 points (terminals) of inputs and outputs is shown in Fig. 9.
The implementation of frame KEB models opens new opportunities for developers in the topology and architecture of SDSSSN.

In SDSSSN on the basis of KEB-1, KEB-2, branched, unbranched, rectilinear, curvilinear connections i.e. communication channels, transmitting information in any given direction, are synthesized.

Branching communication channels allow information to be transmitted from one terminal point, the SDSSSN input to several outputs.

In such SDSSSNs, it is possible to form intersecting communication channels between inputs and outputs located in different parts thereof.

In some cases in flat homogeneous SDSSSN, limiting the transfer of information from one part of the structure to another or even isolating one part from the other, communication channels may be formed.

The implementation of KEB-1, KEB-2 in the synthesis of new SDSSSN allows the more efficient and full use of the structure (Fig. 10, 11).

Fig. 9. Traditional file-switching structure model

Fig. 9. Traditional file-switching structure model

Fig. 10. 3D rectangular colored frame model KEB switching structure from $N = 2$ generating of KEB-1 (green, red)
3D rectangular colored frame model switching structure on the $KEB$ from $N=2$ generating $KEB-1$ (blue-black, red) and 6 input-outputs $A_{ij}, B_{ij}, C_{ij}, D_{ij}, F_{ij}, E_{ij}$.

The interaction of different types of models ($KEB-1, KEB-2$) as augmented reality tools (contributes individual artificial elements to the perception of the real world) or knowledge base rules, their reuse in the modeling infrastructure is provided on the basis of the problem-oriented integration method.

The implementation of the method allows solving the problems of compatibility and interaction of models in the object-oriented modeling infrastructure intended for the work of SDSSSN designers.

3D rectangular colored frame model switching structure on the $KEB$ from $N=2$ generating $KEB-1$ (green, red) and 8 input-outputs $A_j, x_k, u_f$, where $i=1, q, j=1, p, k=1, 4, f=1, 4$.

The model description is extended by the semantic constructions of the domain are and the knowledge bases determining the work logic of the models [6].

Regardless of whether the model functions are implemented in a specialized programming language or described in the form of rules, the user will operate them in the same way.

When performing the modeling, each model implements the algorithms embedded in it and interacts with other models through subscriptions to outputs from other models. Subscriptions are implemented on the basis of the constructed information-graphic description.

**FORMATION OF STATES OF COMMUTATION STRUCTURES ON SWITCHING ELEMENTS BY BEREZOVSKY**

These days, one of the topical tasks of designing in many technical branches is the development of efficient switching provision for SDSSSN in various modes of...
their operation [7]. This task, first of all, refers to the switching of complex computer systems and networks, to the management of monitoring systems and security networks, to switching of channel television, broadcasting, telephony and Internet networks, to maintaining the required state of optoelectronic communication networks, etc. [8].

Existing designing methods of appropriate patching facilities for the listed SDSSSN have a number of known shortcomings [9] that reduce the efficiency of multi-channel networks functioning, and therefore the proposed approach, the main concept of discussed below, is of some interest.

So, suppose that for a given SDSSSN containing M channels \( y_k \ (k = 1, M) \), it is necessary to ensure their switching to \( N \) states \( S_i \ (i = 1, N) \) on the basis of commuting module \( (KEB) \). In its turn, the \( KEB \) is characterized by \( n \) commuting variables \( x_r \ (r = 1, n) \) and \( m \) commutated poles (variables) \( z_l \ (l = 1, m) \). Furthermore, for the \( KEB \) there is also a certain number \( Q \) of switching states (SS) \( V_j \ (j = 1, Q) \) with respect to the set of variables \( z \).

Then the task solution on switching the considered SDSSSN can be reduced to the determination of a certain number of \( KEBs \) that, on the basis of a number of states \( V \) under the control of \( n \) commuting variables \( x \), by means of the variables \( z \), ensure the commutation of the channels \( y \) for given states \( S \).

Concurrently, the solution of the problem can be obtained on the basis of different \( KEB \).

One of the simple way of presenting information about a given \( i \)-th SS \( (S_i) \) is shown in Table 1.

**Table 1. Switching state table**

<table>
<thead>
<tr>
<th>( y )</th>
<th>( y_1 )</th>
<th>( y_2 )</th>
<th>\ldots</th>
<th>( y_M )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( y_1 )</td>
<td>0</td>
<td>1</td>
<td>\ldots</td>
<td>0</td>
</tr>
<tr>
<td>( y_2 )</td>
<td>0</td>
<td>0</td>
<td>\ldots</td>
<td>1</td>
</tr>
<tr>
<td>\vdots</td>
<td>\vdots</td>
<td>\vdots</td>
<td>\ddots</td>
<td>\vdots</td>
</tr>
<tr>
<td>( y_M )</td>
<td>0</td>
<td>0</td>
<td>\ldots</td>
<td>0</td>
</tr>
</tbody>
</table>

**Table 2. Modified table**

<table>
<thead>
<tr>
<th>( y )</th>
<th>( y_1 )</th>
<th>( y_2 )</th>
<th>\ldots</th>
<th>( y_M )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( y_1 )</td>
<td>1</td>
<td>1</td>
<td>\ldots</td>
<td>0</td>
</tr>
<tr>
<td>( y_2 )</td>
<td>0</td>
<td>1</td>
<td>\ldots</td>
<td>1</td>
</tr>
<tr>
<td>\vdots</td>
<td>\vdots</td>
<td>\vdots</td>
<td>\ddots</td>
<td>\vdots</td>
</tr>
<tr>
<td>( y_M )</td>
<td>1</td>
<td>0</td>
<td>\ldots</td>
<td>1</td>
</tr>
</tbody>
</table>

Because of the presence of symmetry, Table 1 can be simplified (Table 2).

On the basis of Table 1 and Table 2, it is convenient to introduce the following notation, which in the presence of a connection between the p-th and q-th channels can be represented in the form

\[
y_p y_q = 1,
\]

and in its absence it is written as follows

\[
y_p y_q = 0.
\]

Then, taking into consideration the notations (1) and (2), the \( i \)-th SS \( (S_1) \) can be represented in the form

\[
S_i = g_1(i) + g_2(i) + \ldots + g_{ai}(i) = a_i,
\]

where \( g_1(i) \) is the \( k \)-th connection of channels \( y_p y_q \) (1) to the \( i \)-th SS SDSSSN.
Based on the introduced representations (Table 1, 2, expressions (1)–(3)) as a whole, the task for commutating of SDSSSN can be represented in the form of a table (Table 3).

**Table 3.** Channel Link Combination Table

<table>
<thead>
<tr>
<th>S</th>
<th>g</th>
<th>g1</th>
<th>g2</th>
<th>...</th>
<th>g4</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>g1</td>
<td>1</td>
<td>0</td>
<td>...</td>
<td>0</td>
</tr>
<tr>
<td>S2</td>
<td>g2</td>
<td>1</td>
<td>0</td>
<td>...</td>
<td>1</td>
</tr>
</tbody>
</table>
...   | ...| ...| ...| ... | ...|
| SN   | SNK| 0  | 1  | ... | 0  |

In the Table 3, in line g, all used in SS combinations of SDSSSN channels of the type

\[ g_1 = y_1v_2, \quad g_2 = y_1v_3, \quad ..., \quad g_A = y_{M-1}v_M, \]

are represented, except \( y_kv_j (k = 1,M) \).

The same information (Table 3) can easily be represented in the form of expressions (3)

\[ S_i = \sum_{k=1}^{g_i} a_k(i) = a_i, \quad i = 1, N. \]  

(4)

In particular, the simple inclusion of the SDSSSN, by virtue of relations (4), is described as follows

\[ S_i = \sum_{k=1}^{g_i} g_k(i) = a_i, \quad i = 1, 2, \]

where \( a_1 = 0, \quad S_1 = 0. \)

In its turn, for the KEB it is also possible to create tables similar to those considered above (Tables 1–3). Such tables for KEB are given below (Table 4, 5).

**Table 4.** Variable table

<table>
<thead>
<tr>
<th>z</th>
<th>z1</th>
<th>z2</th>
<th>...</th>
<th>zm</th>
</tr>
</thead>
<tbody>
<tr>
<td>z1</td>
<td>0</td>
<td>1</td>
<td>...</td>
<td>0</td>
</tr>
<tr>
<td>z2</td>
<td>0</td>
<td>0</td>
<td>...</td>
<td>1</td>
</tr>
</tbody>
</table>
...| ...| ...| ... | ...|
| zm| 0  | 0  | ... | 0  |

**Table 5.** Variable table

<table>
<thead>
<tr>
<th>V</th>
<th>w</th>
<th>w1</th>
<th>w2</th>
<th>...</th>
</tr>
</thead>
<tbody>
<tr>
<td>V1</td>
<td>1</td>
<td>0</td>
<td>...</td>
<td>1</td>
</tr>
<tr>
<td>V2</td>
<td>1</td>
<td>1</td>
<td>...</td>
<td>0</td>
</tr>
</tbody>
</table>
...| ...| ...| ... | ...|
| VQ| 0  | 1  | ... | 1  |

Description of the SS KEB by analogy with the expression (4) has the form

\[ V_j = \sum_{z=1}^{b_j} w_r(j) = b_j, \quad j = 1, \overline{Q}, \]  

(5)

where \( w_r(j) \) is the \( r \)-th connection of the variables \( z_1z_m (1) \) in the \( j \)-th SS.

For KEB it is necessary additionally to describe the state of control variables \( x_r \) (control state (CS) \( X_j \)) for each SS \( V_j \) of commutated variables \( z_l (l = 1, m) \) (Table 5). For this purpose it is convenient to use the following table (Table 6).
Table 6. Control signal table

| $x_1$ | 0 | 0 | ... | 1 | 1 |
| $x_2$ | 1 | 1 | ... | 0 | 0 |
| ... | ... | ... | ... | ... | ... |
| $x_n$ | 0 | 1 | ... | 0 | 1 |
| $V$   | $V_1$ | $V_2$ | ... | $V_{Q-1}$ | $V_Q$ |

In Table 6 the agreed notation is as: 1 — has a control signal and 0 — this signal is not present that can be represented for the $k$- th manipulated variable in the following form

$$x_k = 1 \quad \text{или} \quad \overline{x_k} = 0, \quad k = 1, n.$$  
(6)

Then the description of the $j$-th CS ($X_j$) for the $j$-th SS ($V_j$) has the form

$$X_j = x_1x_2x_3...x_n.$$  
(7)

Taking into consideration the relations (6) and (7), and also the well-known Boolean algebraic identities for the representation (5), we obtain

$$V_j = b_j X_j = b_j (\overline{x_1x_2x_3...x_n}), \quad j = 1, Q.$$  

Indeed, by virtue of Table 6 and the expressions (6), (7), for $V_j$ we have

$$X_j = x_1x_2x_3...x_n = 1.$$  

It should be noted that, both for SS $SDSSSN$ ($S_i$), and SS $KEB$ ($V_j$) the simple and / or complex switching occurs. The first type of commutation is characterized by the absence of repetition of indices in the description of $g_k(i)$ (4) and $w_r(j)$ (5), i.e. each $SDSSSN$ channel and each $KEB$ pole has only one connection. Complex switching allows the repetition of mentioned indices, which indicates the presence of several connections for individual channels of the $SDSSSN$ and $KEB$ poles. The noted features impose additional requirements on the formation process of the complex $SDSSSN$ set by SS, which determines the development of individual methods for solving the set task.

So, the first procedure for the formation of complex $SDSSSN$ assigned by SS is called the method of direct substitution (MDS) and its essence is as follows.

Suppose that for $SDSSSN$ with $M$ channels $y_k$ ($k = 1, M$) it is required to form $N$ SS $S_i$ ($i = 1, N$) based on KEB with $n$ commuting variables $x_r$ ($r = 1, n$), $m$ commutated poles $z_l$ ($l = 1, m$) and $Q$ SS $V_j$ ($j = 1, Q$). In the above descriptions (4) and (5) the representation of this problem has the form ($Q \geq N$, $m \geq M$):

$$\sum_{k=1}^{M} g_k(i) = a_i, \quad i = 1, N; \quad \sum_{z=1}^{b_j} w_r(j) = b_j, \quad j = 1, Q,$$  
(8)

where

$$g_1(i) = y_1y_2, \quad g_2(i) = y_1y_3, \quad ..., \quad g_{m-1}(i) = y_1y_m;$$
3D Frame models switching elements by Berezovsky for software-configurable switching structures

\[ g_m(i) = y_2y_3, \quad g_{m+1}(i) = y_2y_n, \quad \ldots, \quad g_{2m-3}(i) = y_2y_m; \]

\[ g_c(i) = y_{m-1}y_m. \]  \hspace{1cm} (9)

For \( w_j(j) \) the relations analogous to the equalities for \( g_k(i) \) (8) are valid. Obviously, for \( m > 0 \), the individual values of \( g_k(i) \) (9) are equal to zero by definition \( (g_M(i) = y_1y_{M+1} = 0 \text{ etc.}) \).

MDS provides for the identification of all possible solutions to the formulated above task. For this purpose, at each step of identifying connections between the channels \( y_k (k = 1, M) \) of SDSSSN and \( z_l (l = 1, m) \) KEB bands, these connections are set in the following form based on some search algorithm or randomly

\[ y_1 = z_{\alpha}, \quad y_2 = z_{\beta}, \ldots, \quad y_m = z_{\omega}. \]  \hspace{1cm} (10)

Subsequently the SS SDSSSN \( S_i (i = 1, N) \) (8), (9) are rewritten taking into account the selected combinations (10) in the form:

\[ \sum_{k=1}^{ali} w_k(i) = a_i, \quad i = 1, N, \]  \hspace{1cm} (11)

and the following equalities are considered separately for each \( S_i (i = 1, N) \):

\[ V_j - S_1 = b_j - a_1, \quad j = 1, Q; \]
\[ V_j - S_2 = b_j - a_2, \quad j = 1, Q; \]
\[ \ldots \ldots \ldots \ldots \ldots \ldots \]
\[ V_j - S_N = b_j - a_N, \quad j = 1, Q. \]  \hspace{1cm} (12)

The presence of non-coincident values of \( j \) for each SS \( S_i (i = 1, N) \) indicates the correctness of the selected compounds (10). Violation of this requirement determines the inaccuracy of the relations (10). Herewith, description of the control variables \( x_r (r = 1, n) \) (7) \( X_i \) corresponds to each value of \( j (V_j) \) entering into the obtained solution.

In particular cases, to solve the set task, the tables of SS indices (S1, Table 7 and \( V_j \), Table 8) can be used.

<table>
<thead>
<tr>
<th>Table 7. Index table</th>
</tr>
</thead>
<tbody>
<tr>
<td>( S )</td>
</tr>
<tr>
<td>( g_1 )</td>
</tr>
<tr>
<td>( S_1 )</td>
</tr>
<tr>
<td>( S_2 )</td>
</tr>
<tr>
<td>( \vdots )</td>
</tr>
<tr>
<td>( S_N )</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 8. Index table</th>
</tr>
</thead>
<tbody>
<tr>
<td>( V )</td>
</tr>
<tr>
<td>( w_1 )</td>
</tr>
<tr>
<td>( V_1 )</td>
</tr>
<tr>
<td>( V_2 )</td>
</tr>
<tr>
<td>( \vdots )</td>
</tr>
<tr>
<td>( V_O )</td>
</tr>
</tbody>
</table>

A simple search of lines in the Table 8, overlapping the lines in the Table 7, in the absence of their overlapping for different \( S_i (i = 1, N) \), also proves the correctness of the selected connections (10).
EXAMPLE OF APPLYING THE PROPOSED METHOD

To illustrate the proposed MDS, let’s consider the following simple example. For a certain MCS having 4 channels \( y_k \) \( (k = 1,4) \), based on the given tables of the type of Table 1-3, a SS (4) \( S_i \) \( (i = 1,2) \) are created:

\[
S_1 = y_1y_3 + y_2y_4 = 2; \quad S_2 = y_1y_2 + y_3y_4 = 2. \tag{13}
\]

In addition, there is a KEB with 6 poles \( z_i \) \( (i = 1,6) \) and 10 control variables \( x_r \) \( (r = 1,10) \). To provide the SS (11) in the CM, the following SS \( (V_j) \) (5) can be used:

\[
V_1 = z_1z_4 + z_2z_3 + z_2z_5 = 3; \\
V_2 = z_1z_5 + z_2z_4 + z_3z_6 = 3; \tag{14} \\
V_3 = z_1z_3 + z_2z_4 + z_5z_6 = 3.
\]

Taking into consideration the representation (9) of the SS description (14) will take the form:

\[
V_1 = w_3(1) + w_6(1) + w_6(1) = 3; \\
V_2 = w_4(2) + w_7(2) + w_{12}(2) = 3; \tag{15} \\
V_3 = w_2(3) + w_7(3) + w_{15}(3) = 3.
\]

The description of control variables (7) corresponds to each SS (14), (15)

\[
X_1 = x_1x_2\ldots x_{10}, \quad X_2 = x_1x_2\ldots x_{10}, \quad X_3 = x_1x_2\ldots x_{10}. \tag{16}
\]

Next, the connections (10) are assigned

\[
y_1 = z_1, \quad y_2 = z_2, \quad y_3 = z_3, \quad y_4 = z_4, \tag{17}
\]

and expressions (11), (13) are written down,

\[
S_1 = w_2(1) + w_7(1) = 2; \quad S_2 = w_1(2) + w_{10}(2) = 2. \tag{18}
\]

The verification of conditions (12) on the basis of expressions (18) and (15) gives the following relations:

\[
V_1 - S_1 = 3; \quad V_2 - S_1 = 2; \quad V_3 - S_1 = 1; \quad V_1 - S_2 = 3; \quad V_2 - S_2 = 3; \quad V_3 - S_2 = 3. \tag{19}
\]

In the set \( V_j - S_1 \) \( (j = 1,3) \) there is a solution \( (V_3 - S_1 = 1) \), however there is no such solution in the second set \( V_j - S_2 \) \( (j = 1,3) \) which indicates the unsuccessful selection of connections (17).

The same conclusion can be made as well for example with respect to the following combinations:

\[
y_1 = z_1, \quad y_2 = z_3, \quad y_3 = z_4, \quad y_4 = z_5; \quad y_1 = z_3, \quad y_2 = z_4, \quad y_3 = z_5, \quad y_4 = z_3,
\]

\[
y_3 = z_5, \quad y_4 = z_6; \quad y_1 = z_6, \quad y_2 = z_5, \quad y_3 = z_4, \quad y_4 = z_3
\]

and etc.
The following relation is considered as successful:
\[ y_1 = z_1, \quad y_2 = z_4, \quad y_3 = z_5, \quad y_4 = z_2, \quad (20) \]
which determines a SS of the form (18):
\[ S_1 = w_4(1) + w_7(1) = 2; \quad S_2 = w_5(2) + w_8(2) = 2. \]

In this case, the verification of the requirements (12), (19) has the form:
\[ V_1 - S_1 = 3; \quad V_2 - S_1 = 1; \quad V_3 - S_1 = 2; \]
\[ V_1 - S_2 = 1; \quad V_2 - S_2 = 3; \quad V_3 - S_2 = 3. \]

The second relation \( (V_2 - S_1 = 1) \) from the first set \( V_j - S_j \ (j = 1,3) \) and the first equality \( (V_1 - S_2 = 1) \) from the second set satisfies the requirements (12) and, consequently, the connections (20) are the solution of the problem under consideration. Fig. 12, a) shows the realization of \( S_1 \) (13), and in Fig. 12, b) there is the realization of \( S_2 \) (13) by means of SS KEB, respectively, \( V_2 \) and \( V_1 \). The control variables \( X_2 \) and \( X_1 \) are then fed to the control circuit (CC) KEB respectively (16). In the first case (Fig. 12, a), there is a simple connection, and in the second case (Fig. 12, b) there is a double connection for \( Z_2 \).

The use of index tables (Table 7 and Table 8) gives a fairly clear idea of the presence and absence of a solution.

Thus for the variant of combinations (17) we have the following tables of indices (Table 9, 10).

**Table 9.** Index table for a variant of combinations (17)

<table>
<thead>
<tr>
<th>( S )</th>
<th>( g )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( S_1 )</td>
<td>( g_1 )</td>
</tr>
<tr>
<td>( S_2 )</td>
<td>2</td>
</tr>
</tbody>
</table>

**Table 10.** Index table for a variant of combinations (17)

<table>
<thead>
<tr>
<th>( V )</th>
<th>( w )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( V_1 )</td>
<td>3</td>
</tr>
<tr>
<td>( V_2 )</td>
<td>4</td>
</tr>
<tr>
<td>( V_3 )</td>
<td>2</td>
</tr>
</tbody>
</table>

**Fig. 12.** Implementation of SDSSSN \( S_1 (a) \) and \( S_2 (b) \)

These tables (Table 9, 10) obviously demonstrate the abovementioned conclusions (19) on the absence of a solution.

For correct connections (20), there are the tables 11 and 12 take place, which convincingly illustrate the existence of a solution to the problem.
In conclusion, we note that the proposed method has its advantages and disadvantages. Thus, SDSSSN (8)–(12) allows to get all possible solutions, it is simply algorithmized and easily allows to take into account additional requirements when selecting connections. These requirements include restrictions on currents, voltages, power, speed, SDSSSN channels and their coordination with the KEB capabilities.

Frame 2D, 3D models of switching elements by Berezovsky give the researcher the opportunity to create their own multi-character material as an innovative database of interactive graphic data (DB) for the formation of special knowledge bases (KB).

Having a language system with which you can present the result and experience of developing a database, and also store and store knowledge bases directly in the system in close connection with a specific sensory channel of cognitive graphics [10].

Such a technology gives a researcher a highly efficient technical tool for direct, purposeful influence on the processes of figurative thinking of a person / developer / operator, and in natural (rather than model or test) conditions for finding a solution to a real scientific problem.

**CONCLUSIONS**

2D, 3D frame models by Berezovsky patented switching elements are proposed for constructing topologies of software-configured switching structures, systems and networks.

The proposed KEB-1 and KEB-2 can be in one of the specified states of Ni; a priori set each state of the switching elements by Berezovsky, which form the topology, is encoded by the logical statement Aj and can be represented as a graphical 2D, 3D model of the image of the SDSSSN element.

Models allow to visualize 2D, 3D topology of the SDSSSN.

They reflect the vision in the design of the role and place of cognitive graphics in the development of new SDSSSNs.

Reduction of various types of models (KEB-1, KEB-2) to single components of the modeling environment allows the designer-designer to build universal models of the SDSSSN, applying various options for the implementation of sub-models.

A distinctive feature of the use of the KEB is the simplification of the procedure for the mathematical design of 2D, 3D models of the SDSSSN topology.

**Table 11.** Index table for correct connections (20)

<table>
<thead>
<tr>
<th>$S$</th>
<th>$g$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$g_1$</td>
<td>4</td>
</tr>
<tr>
<td>$g_2$</td>
<td>7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>$S_1$</th>
<th>$S_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>7</td>
<td>8</td>
</tr>
</tbody>
</table>

**Table 12.** Index table for correct connections (20)

<table>
<thead>
<tr>
<th>$V$</th>
<th>$W$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$w_1$</td>
<td>$w_2$</td>
</tr>
<tr>
<td>$V_1$</td>
<td>3</td>
</tr>
<tr>
<td>$V_2$</td>
<td>4</td>
</tr>
<tr>
<td>$V_3$</td>
<td>2</td>
</tr>
</tbody>
</table>
The use of models $KEB\text{-}1$ $KEB\text{-}2$ allows visualizing the task of designing a given topology of the RCSS parallel systems for collecting and processing, storage of information.

**REFERENCE**


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