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## ЕЛЕКТРОНІКА. РАДІОТЕХНІКА. ЗАСОБИ ТЕЛЕКОМУНІКАЦІЙ

**UDC 681.5; 004.92**

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# 3D MODELS OF SWITCHING PATTERNS OF SWITCHING PLANTS ON ELEMENTS BY BEREZOVSKY

*С.О. Березовський.* **3D моделі комутаційних патернів комутаційних фабрик на елементах Березовського.** Особливість сучасних комутаційних структур, систем, мереж (КССМ) – двомірна (2D) топологія, яка застосовується в багатьох комерційних системах. Традиційні КССМ відрізняється регулярністю, але статичні не відповідають швидкій динаміці розвитку сучасного IT–бізнесу, управління пристроями є розподіленим і занадто складним, або неефективним. Засоби побудови сучасних мереж є проприетарними, закритими для змін з боку власників мереж і наукової громадськості. Нова парадигма побудови КССМ – топологія, що програмно конфігурується, в якій рівень управління є відділеним від пристроїв передачі даних і реалізується програмно простіше і відповідно дешевше. Розглядається перспективне інтелектуально-евристичне рішення створення єдиного універсального інструментарію для вирішення проблеми синтезу нових 2D- і особливо, 3D-топологій КССМ в відомих просторах з використанням елементів когнітивної графіки – образного представлення інформації. Уводиться поняття «комутаційний паттерн»: на фізичному рівні запатентований комутаційний елемент Березовського (КЕБ) та його умовне графічне позначення – графічна лінія другого порядку – еліпс. Побудова 3D-реконфігурованих і програмованих комутаційних структур, систем, мереж (ПКССМ) для паралельних структур інформаційних і телекомунікаційних систем передбачає пошук і розробку нових просторових архітектурно-топологічних рішень і нових 3D-умовно-графічних позначень (УГП), інтелектуальних евристичних фреймових моделей для утворюючих комутаційних елементів. 3D моделі дають досліднику можливість створити власний полізнаковий матеріал як інноваційну базу інтерактивно-графічних даних для формування надалі спеціальної візуальної бази знань і включити людину / розробника / оператора в процес вирішення реальної наукової проблеми в діалоговому режимі. Запропонований підхід допоможе: створити середовище для автоматизації проектування і контролю; забезпечити видимість усього трафіку контролером і безпосередньо висувати певні вимоги до ПКССМ та запитувати інші функціонали для майбутніх додатків.
*Ключові слова*: комутаційний елемент Березовського, 3D комутаційний патерн елементів Березовського, комутаційна фабрика

*S. Berezovsky.* **3D models of switching patterns of switching plants on elements by Berezovsky.** A feature of modern switching structures, systems, networks (SSSN=3SN) is a two-dimensional (2D) topology that is used in many commercial systems. Traditional SSSN is regular, but static – do not correspond to the rapid dynamics of the development of modern IT business; device management – distributed and too complex, not effective. Means of building modern networks are proprietary, closed for changes on the part of network owners and the scientific community. The new paradigm of building the 3SN is a software-configurable topology in which the level of control is separated from the data transfer devices and implemented programmatically, more simply and accordingly cheaper. In the article, a persuasive intellectual – heuristic solution is considered – creating a single universal tool for solving the problem of synthesizing new 2D and, especially, 3D topologies of SSSN in known spaces using elements of cognitive graphics-image information. The concept of switching pattern is introduced: at the physical level, the patented by Berezovsky switching element (SEB) and its conventional graphic designation-the second-order graphic line-is an ellipse. The construction of 3D reconfigurable and programmable switching structures, systems, networks (P3SN) for parallel structures of information and telecommunication systems involves the search for and development of new spatial architectural and topological solutions and new 3D conditional graphic symbols for the generating switching elements. 3D models give the researcher the opportunity to create his own polysemy material as an innovative database of interactive graphics to form a special visual knowledge base and to include the person / developer / operator in the process of solving a real scientific problem in an interactive mode. The proposed approach will help: create an environment for the automation of design and control; ensure the visibility of all traffic by the controller and request directly defined requirements for the P3SN and other functions for future applications.
*Keywords:* Berezovsky switching element, 3D switching pattern by Berezovsky elements, switching plant

**Introduction** One of the main components of the structure of information systems (IS) are switching fields, factories. Their rational design makes it possible, at minimum equipment costs, to

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ensure the integration of processors and memory modules, to create a distributed network of workstations, and also to organize input / output of supercomputers and high-performance servers.

Non-blocking and tunable switching structures (SS), while ensuring high flexibility and completeness of switching, still remain quite complex in structure and, accordingly, require complex management.

A new paradigm for designing large switching structures of SDN, which is based on the separation of planes (Data Plane data, management and Control Plane applications) is a strategic factor in the development of modern IT. That allows for theoretically unlimited possibilities of scalability and performance depending on the tasks to be solved. At the same time, the environment has the necessary "intelligence", in particular, to orchestrate the operation of switching structures and factories of different topologies.

SS should respond quickly to emergencies, generate appropriate signals, automatically switch to backup resources, restore their working capacity and have survivability.

**Analysis of publications and statement of the problem.** A feature of modern SS is a two-dimensional (2D) topology, which is used in many commercial systems. It is regular and easily scaled upwards.

Attempts to change the existing SS were made quite often [1]. However, making fundamental changes to the existing network architecture is very difficult, as it requires the involvement of manufacturers of telecommunications equipment. In addition, the means of building modern networks are proprietary, closed to change by network owners and the scientific community. Always when changing architecture, the transition from the equipment of one manufacturer to the equipment of another is a difficult task, requiring large financial resources.

A special problem of SS is the absence of modern conditional-graphic designations (CGD) of switching elements for constructing spatial multidimensional SS.

The use of reprogrammable 2D, 3D switching structures on Berezovsky elements allows eliminating the urgency of some problems when solving the listed problems [2, 3].

**Objective**. Building 3D reconfigurable and programmable switching structures, systems, networks (SSSN) for parallel structures of information and telecommunication systems involves finding and developing new spatial architectural topological solutions, as well as new 3D conditional-graphic designations (CGD) of intelligent heuristic frame models for generating patented *N*-dimensional switching elements of Berezovsky.

3D models give the researcher the opportunity to create their own multi-character material as an innovative database of interactive graphic data to form, in consequence, a special visual knowledge base. In addition, to include a person / developer / operator in the process of solving a real scientific problem in an interactive mode.

**2D and 3D basic frame models of switching elements of Berezovsky**. To solve the problem, frame forming switching elements were synthesized and patented [2, 3]:

Berezovsky switching element (*SEB*) (symbol $\underline{B^{\#}}$),

*N*-dimensional switching element of Berezovsky (symbol $\underline{B_N^{\#}}$).

The main advantages of the *SEB* are full availability and minimal delays.

Switching elements of Berezovsky $\underline{B^{\#}}$ or $\underline{B_N^{\#}}$ when *N*=1 are used as switching frameworks.

A *SEB* can be in one of a given set of states of Ni. Each state of a *SEB* is encoded by a logical statement *Wj* and can be represented as an image – a 2D graphic model (Fig. 1), formed in the mind of the recipient in Fig. 1 [4].

Performing various geometric transformations with models of the *SEB* framework, topological solutions are possible, shown in Fig. 2, 3.

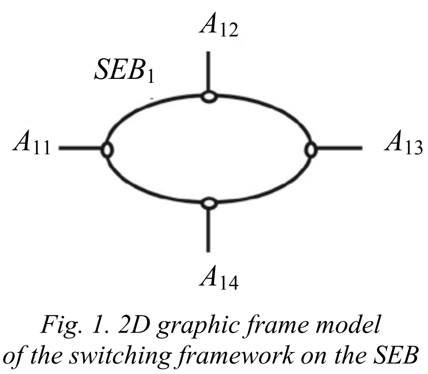


*Fig. 1. 2D graphic frame model of the switching framework on the SEB*

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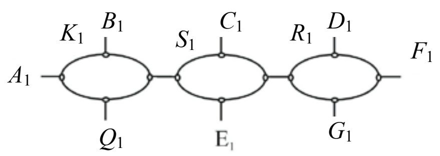


*Fig. 2. Horizontal uncolored switching module on SEB*

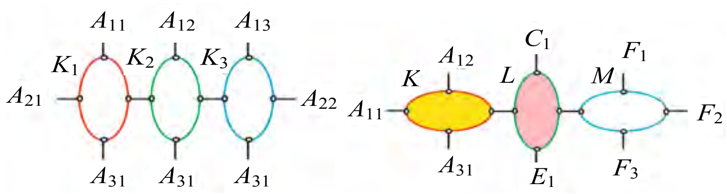


*Fig. 3. Horizontal colored switch module on SEB*

Models allow you to visualize information about the topology, composition and states of individual elements of switching structures on the *SEB*.

The physiological peculiarity of the human – operator to perceive the light electromagnetic radiation with the eye, transform and "reflect" information about this radiation in the brain in the form of associative images, expands the possibilities of using image models and allows the designer in natural conditions to be included in the search for a solution to a real scientific problem.

Horizontal packed module (GM) of Berezovsky's uncolored switching elements $\underline{B^{\#}_{N2}}(B/W)$, $F := \left[\!\left[ \underline{B^{\#}_{N2}}(RGB)[k \gg GP_{1q} \ll l\ ] \right]\!\right]$ where $n$=1, $m$–3 shown at Fig. 3, colored – $F := \left[\!\left[ \underline{B^{\#}_{N2}}(RGB)[k \gg GP_{1q} \ll l\ ] \right]\!\right]$ at Fig. 4. $F_{2L} := \left[\!\left[ \underline{B^{\#}_{N2}}(RGB)[k \gg GP_{1q} \ll l] \right]\!\right]$.

The model of the Berezovsky switching element framework can be presented in black and white variant $\underline{B^{\#}_{N2}}(B/W)$, color variant without specifying the used color model $\underline{B^{\#}_{N2}}(C)$ or specifying, for example $\underline{B^{\#}_{N2}}(RGB)$, or $\underline{B^{\#}_{N2}}(HEX)$ Fig. 5.

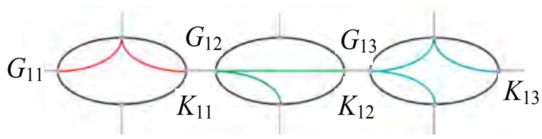


*Fig. 4. Horizontal uncolored switching module with states of the SEB*

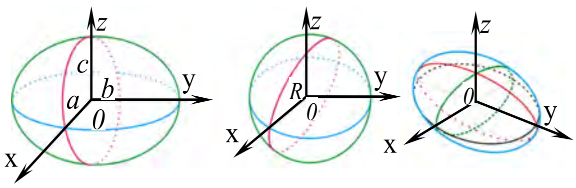


*Fig. 5. Second-order algebraic closed lines*

The state of the framework $\underline{B^{\#}}(RGB)$ is given by the characteristic equations *Wj* [3] and it is proposed to reflect using the first and second order algebraic lines between the "input – output" terminals in Fig. 4.

Using the central nondegenerate curve of the second order – an ellipse, as a 2D conditional graphic designation (CGD) of the image model of the *SEB* framework with the ability to visualize its state, turned out to be very convenient and visual.

A well-chosen 2D graphical model of the switching framework has allowed us to develop a number of intellectual–heuristic frame topologies on Berezovsky elements in polar coordinates [5].

**3D frame models of *SEB*.** A more complex option is three-dimensional topology, technology, representing complex shapes and surfaces [6].

3D conditional graphic designation (3D CGD) is a graphical model of the framework. This is the geometric locus of points (GLP) and can be represented by an equation of general form:

$$F(x, y, z) = 0,$$

where each point will have three coordinates in some designated basis.

The full painted form of equality is:

$$a_{11}x^2 + a_{22}y^2 + a_{33}z^2 + 2a_{12}xy + 2a_{23}yz + 2a_{13}xz + 2a_{14}x + 2a_{24}y + 2a_{34}z + a_{44} = 0, \quad (1)$$

where $a_0$, $a_1$, …, $a_n$, – real numbers (coefficients of a polynomial) some constants;

*x, y, z* – variables corresponding to the affine coordinates of a point, but not any point will correspond to the equation.

With the degeneration of the GLP (i.e., when one of the coordinates is constant or equal to zero in the entire range of permissible values), many numerical factors are identically equal to zero. Then the equation is greatly simplified, i.e. 3D models are replaced by projections as 2D models.

A closed second-order algebraic line – an ellipse (the canonical equation is obtained by simple transformations from (1)) is the generator for the formation of second-order surfaces – the ellipsoid and the sphere (Fig. 5).

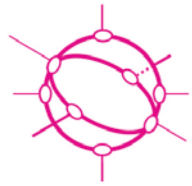

*Fig. 6. Pattern on the SEB*

Such an approach will allow the use of second-order surfaces ellipsoid and sphere as 3D CGD-frame models of the SEB framework.

**Switching patterns on the *SEB*.** The algebraic lines and second-order surfaces are used to generate new models – switching *N*-dimensional patterns on *N*-dimensional *SEB*.

Earlier it was noted that the model of the Berezovsky switching element framework can be presented in black and white $\underline{B^{\#}_{N2}}(B/W)$, in color $\underline{B^{\#}_{N2}}(C)$ without specifying the color model used or indicating, $\underline{B^{\#}_{N2}}(RGB)$ for example.

Consider a pattern on the *SEB* from a combination of an ellipse and a circle. Fig. 6.

The metric of the switching pattern $P_{1q}$ on the *SEB* in this example is *N*=2.

The first color (Orchid) switching pattern $P_{1q}$ on the *SEB*:
$P_{1q} := \bigcup_{j=2} \underline{B^{\#}_{N2}}(RBG)$ with color codes

$$P_{1q} := \bigcup_{j=2} \underline{B^{\#}_{N2}}(218, 112, 214).$$

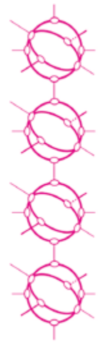

*Fig. 7. Linear color switching fabric*

We use the synthesized switching pattern $P_{1q}$ to build a homogeneous vertical module on the *SEB*, as a new topology, the frame model of a linear switching factory:

$$F_{1L} := \left\llbracket \underline{B^{\#}_{N2}}(RGB)[n \curlyvee VP_{1q} \curlywedge m\ ] \right\rrbracket.$$

In our example $F_{1L} := \left\llbracket \underline{B^{\#}_{N2}}(218, 112, 214)[n \curlyvee VP_{1q} \curlywedge m\ ] \right\rrbracket$ is shown in Fig. 7.

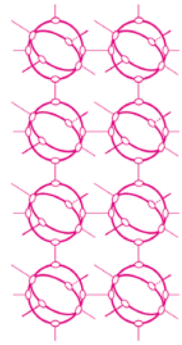

*Fig. 8. Vertical packaged color switching fabric*

The model of a vertical packed color switching fabric in the form of a plane of two vertical patterns $F_{1L}$ is shown in Fig. 8, 9.

$$F_{2P} := \left\{ \sum_{i=1}^{h} F_{1L} \right\},$$

$$F_{2P} := \left\{ \sum_{i=1}^{2} \left\llbracket \underline{B^{\#}_{N2}}(RGB)[n \curlyvee VP_{1q} \curlywedge m\ ] \right\rrbracket \right\}$$

or for our case

$$F_{2P} := \left\{ \sum_{i=1}^{2} \left\llbracket \underline{B^{\#}_{N2}}(218, 112, 214)[1 \curlyvee VP_{1q} \curlywedge 4\ ] \right\rrbracket \right\}.$$

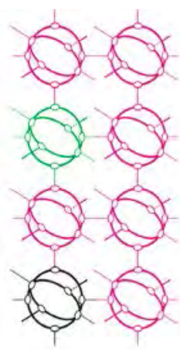

*Fig. 9. Vertical packaged combined switching fabric*

A variant of a linear horizontal packed colored switching factory at the *SEB* is shown in Fig. 10.

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$$F_{2L} := [\![ \underline{B^{\#}_{N2}}(RGB)[k \gg GP_{1q} \ll l] ]\!],$$

$$F_{2L} := [\![ \underline{B^{\#}_{N2}}(000, 255, 127)[1 \gg GP_{1q} \ll 4] ]\!],$$

$$F_{3P} := \left\{ \sum_{i=1}^{h} F_{2L} \right\},$$

$$F_{3P} := \left\{ \sum_{i=1}^{2} [\![ \underline{B^{\#}_{N2}}(RGB)[n \gg GP_{1q} \ll m] ]\!] \right\}$$

or for our case (Spring green color)

$$F_{3P} := \left\{ \sum_{i=1}^{2} [\![ \underline{B^{\#}_{N2}}(218, 112, 214)[1 \gg GP_{1q} \ll 4] ]\!] \right\}.$$

Intelligent CAD systems based on languages of five levels are able to generate homogeneous topologies automatically, creating new information visualization, based on existing graphic examples-images.

**3D models of switching patterns of factories on the elements of Berezovsky.** Solving the image of the topology of the P3SN, in addition to the Cartesian rectangular coordinate system, you can use different coordinate systems, choosing the one in which the task of visualizing information is solved more easily or more conveniently in this particular case.

Using the 3D image method of topological solutions of the P3SN on the plane using parallel projections, it is possible to present the discussed above models of linear switching vertical and horizontal patterns of linear switching factories in a perspective view. Fig. 11.

Applying the operations of displacement and transfer to axonometric models of switching patterns on the SEB, it is proposed to form vertical and horizontal fields – the planes of switching factories (Fig. 12, 13) and form switching masters patterns. Fig. 14.

*N*-dimensional crystal-cubic topology of the switching factory on the *SEB* is formed from a set of (*N*–1)-planes – fields of switching patterns, based on switching patterns, for example, $F_{1L} F_{2L}$ (Fig. 15).

Unified switching factories are created to uniquely integrate with servers, storage systems, and orchestration platforms in order to simplify the administration of the network as a whole. As well as for more efficient operation, increasing the level of fault tolerance, ensuring the maximum level of scalability, reducing energy consumption; reduction of operating costs [7].

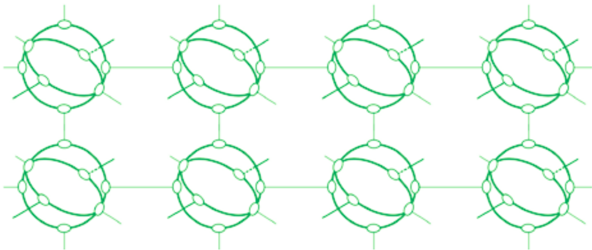

*Fig. 10. Linear horizontal packed colored switching factory at the SEB*

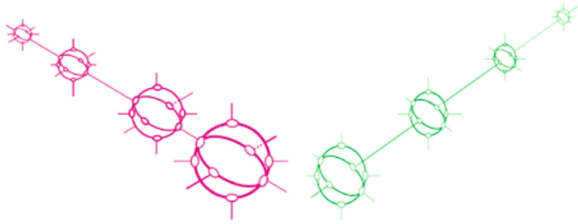

*Fig. 11. Axonometric models of switching patterns, $F_{1L}$, $F_{2L}$*

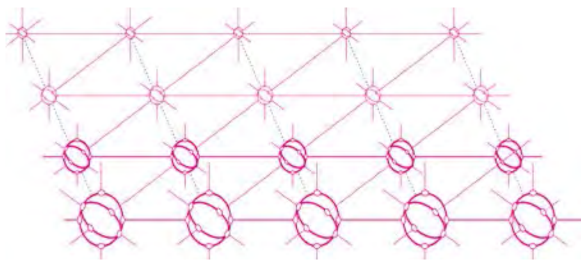

*Fig. 12. Horizontal field – the plane of the switching factory*

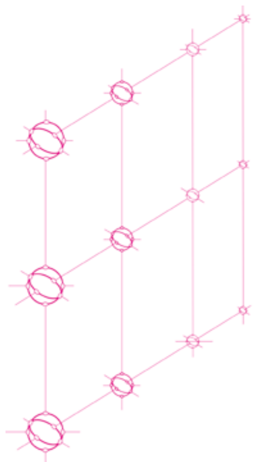

*Fig. 13. Horizontal field – the plane of the switching factory*

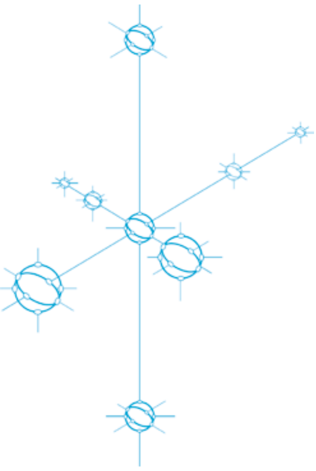

*Fig. 14. Switching master pattern*

The switching factory has a revolutionary 3D homogeneous architecture. This approach allows you to eliminate the loss of time to reconfigure the factory due to the lack of a dedicated switching master pattern. If necessary, you can specify – select the switching master pattern or remove it from the topology. Figs. 15, 16.

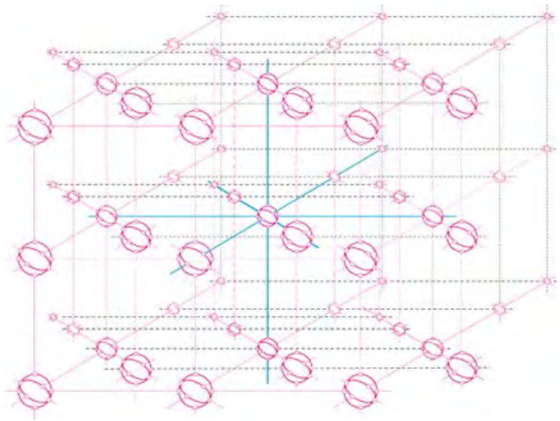

*Fig. 15. The N-dimensional crystal-cubic topology of the switching factory on the SEB with a dedicated switching master pattern (marked in blue)*

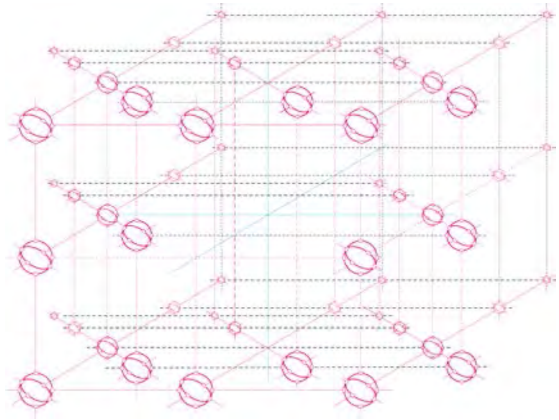

*Fig. 16. The N–dimensional crystal–cubic topology of the switching factory on the CEB with the remote (excluded) switching master-pattern (its place is marked in blue)*

Perspective open switching factory on the SEB without an embedded operating system [8].

**3D frame models of matrix switching factories on Berezovsky elements.** The basic idea of switching factories is the multi-stream routing of data (without crossing them) between different information systems (IS) through a single point.

The term "factory" in the context of telecommunication technologies has appeared in relation to the switching matrix. The topology of the matrix can be represented as a grid of vertical and horizontal lines, with its corresponding input and output terminals (ports). Fig. 17, 18 [9].

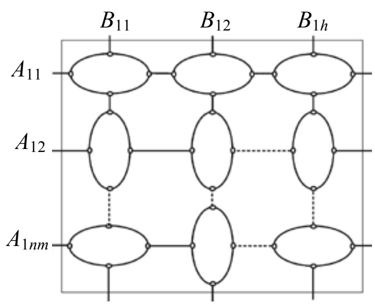


*Fig. 17. Packed planar frame model of the switching matrix on the SEB* $\underline{B^{\#}}$

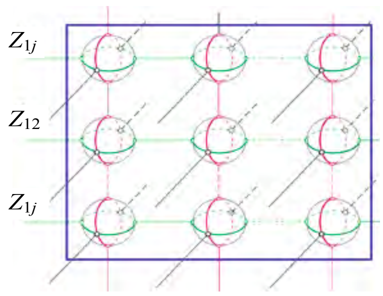


*Fig. 18. Packed planar frame model of the switching matrix on the SEB* $B^{\#}_{N2}$

The *SEB* that form the plane differ in the N metric, i.e. $\underline{B^{\#}} = 1$ by default

$$F_{4P} := \left\{ \sum_{i=1}^{h} \left[\!\left[ \underline{B^{\#}}(B/W)[n \curlyvee VP_{1q} \curlywedge m] \right]\!\right] \right\}$$

and $B^{\#}_{N2}$ metric $N$=2.

$$F_{5P} := \left\{ \sum_{i=1}^{j} \left[\!\left[ \underline{B^{\#}_{N2}}(RGB)[n \curlyvee VP_{1q} \curlywedge m] \right]\!\right] \right\}.$$

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An increase in the CEB metric that forms the pattern provides an increase in the number of input-output contact terminals (ports) of the packed planar frame model of the switching matrix Fig. 19, 20.

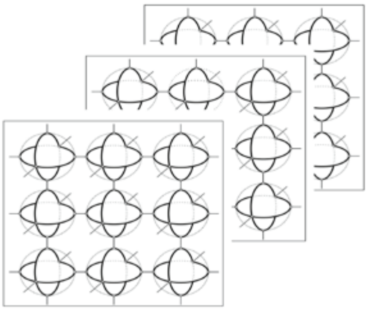

*Fig. 19. 3D packed frame monoblock l-planar uncolored on cartesian patterns with the N=2 metric model of a switching matrix on a SEB*

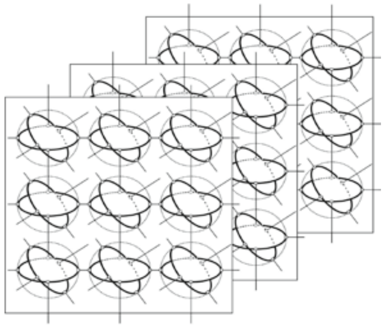

*Fig. 20. 3D packed frame monoblock k-planar uncolored on isometric patterns with the N=2 metric model of a switching matrix on a SEB*

Devices connected to the factory can communicate through multiple ports, as well as use a combination of different paths through the communication medium, which allows for increased fault tolerance and throughput.

The widespread adoption of virtualization requires that the structural construction of the factory provides visibility of traffic in virtual machines when transferring data between them, and also provides the ability to easily connect to the network.

Factories are primarily needed in the data center with their high demands on performance, fault tolerance and support for migrating virtual machines.

The use of switching patterns of *SEB* allows you to synthesize absolutely any physical topology (planes, surfaces, shapes) of the switching factory.

These topologies incorporate a lot of proven ideas, some of which are used in the technologies of forming the *SEB* switching patterns for factories.

Open switching factory on the *SEB* without an embedded operating system Fig. 21.

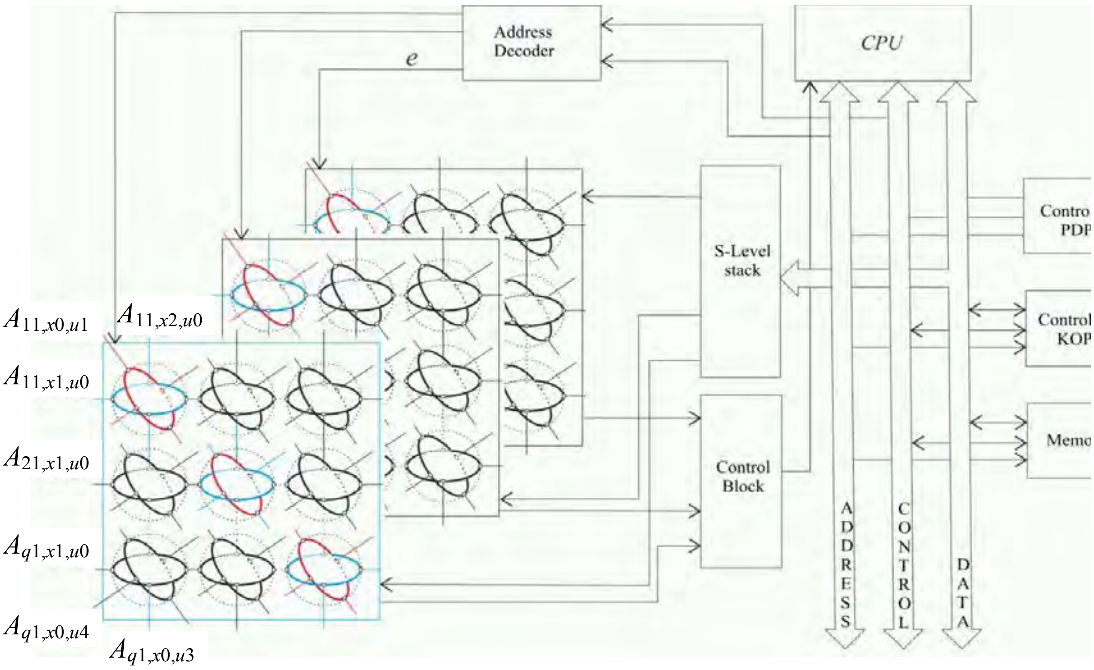


*Fig. 21. The ordinary structure of the switching factory at the SEB*

For example, combining three physical switching multi-plane matrix modules into an intelligent frame multi-pattern $N_i$-dimensional fabric on *SEB* allows you to get a fault-tolerant high-performance platform that you can then cut into the required number of contexts, thus achieving a high level of flexibility Fig. 22.

A wide range of *SEB* switching pattern configurations ensures adaptation to the future growth of data traffic without exorbitant costs.

The new factory has a block/modular architecture that allows users to avoid the need for a complete replacement of equipment when introducing the next generation technologies in their environments.

The switching factory is represented by the 2nd matrix module $M_f$ and $H_u$ on the planar packed switching patterns of the *SEB* Fig. 23.

The main functions of multi-stream data routing fall on the factory–line of controllers $P_r, r = \overline{1,w}$ and consist in determining the information transfer routes, as well as in managing devices processing $Q_e, e = \overline{1,a}$ and balancing data flows.

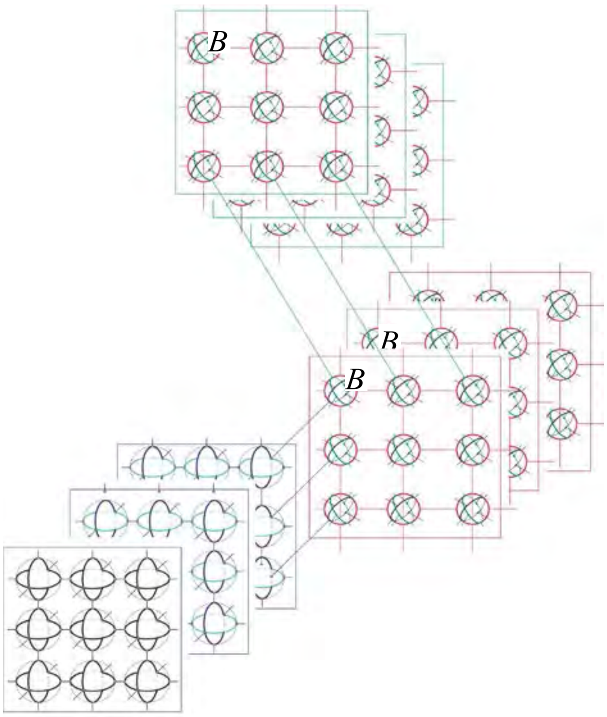


*Fig. 22. Packed 3D intelligent frame q-block multiplane multi-pattern $N_i$-dimensional factory on SEB*

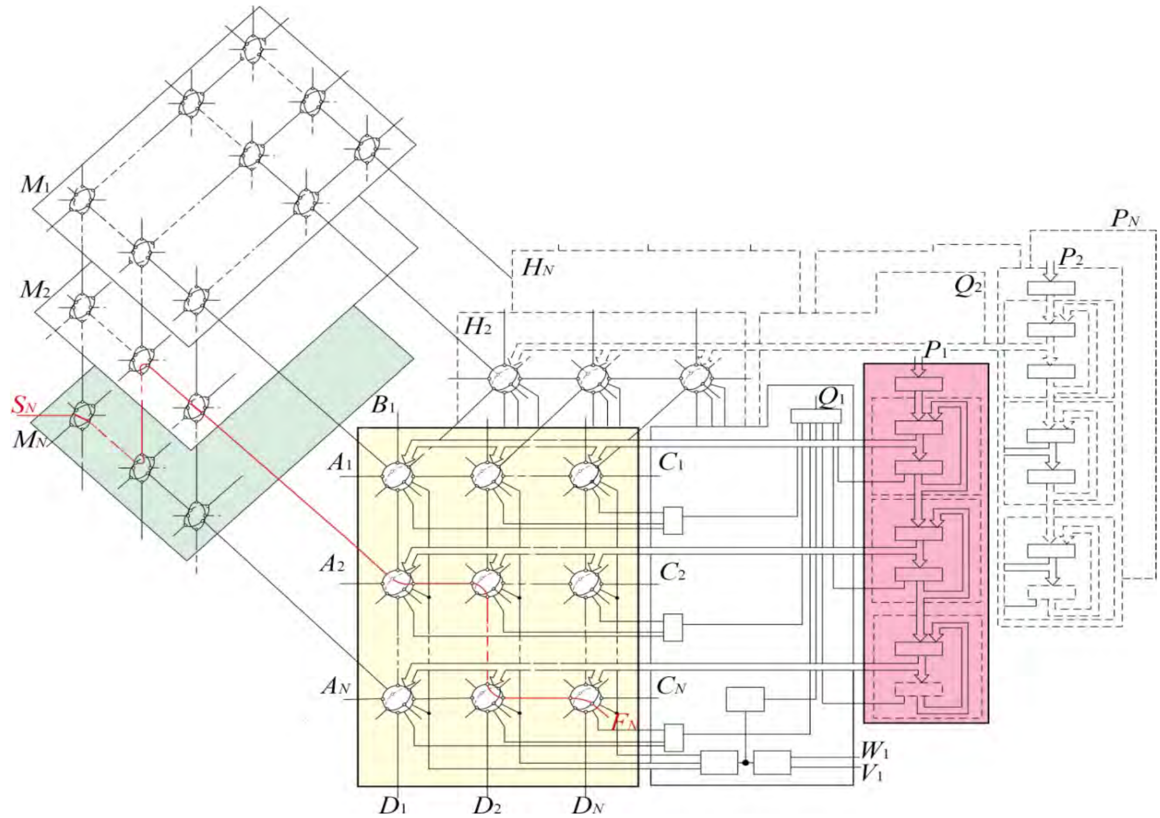


*Fig. 23. Switching factory with block/modular architecture*

A flexible scalable factory structure allows users to start at the size and scale that meets their current needs, while creating the conditions for meeting these needs in the future.

The algorithms and protocols of the control plane, which ensure the interaction of intelligent plane, block–matrix P3SN on the *SEB*, are not included in the topic of work and are not considered [10].

The ability to select hardware and software solutions for all levels of the network stack and pay-as-you-grow payment allows you to start on a small scale and expand the factory gradually, without linking yourself to a fully integrated proprietary solution, and this is the way to create a modern network for the data center.

Based on sample topologies, a visual database of graphical switching patterns is created.

This paper addresses two main problems associated with building such a database:

– selection of examples;

– modeling of examples.

The availability of reference–information visual database of switching patterns will facilitate the development of an application project – the maintenance of a “human–computer” dialogue in the language of graphic images, designed to solve certain telecommunication tasks.

**Conclusions:**

1. 3D-modeling of switching patterns is a revolutionary process of creating new topologies of three–dimensional models of P3SN. The task of 3D-modeling is to develop a visual, three-dimensional, informative, universal image of the switching pattern on the *SEB*.

2. The switch can now be a very simple device, the whole “intelligence” of which resides in a well-protected controller.

3. The work offers three unique contributions:

– creation of intelligent visual images – patterns for the database;

– development of a convenient and simple 3D modeling of the P3SN topologies based on the SEB switching patterns;

– visual database – images is the basis for the subsequent original decisions in the field of visualization of the topological platforms of the P3SN.

4. Frame models of the SEB switching patterns are not only of academic interest. They reflect the vision in the design of the role and place of cognitive graphics in the development of new P3SN.

5. The results of the work can be used in the process of preparation of materials of modern standards of new 3D conditional-graphic designations (CGD) of switching patterns.

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