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Graph visualization in a heterogeneous environment by means of algebra algorithms

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Annotation. In the article the peculiarities of graphs visualization procedures on the plane by using algebra of algorithms is provided. Conducted study showed the lack of means of graphs visualization that would provide the possibility of their implementation in a heterogeneous environment. Taking it into consideration, the authors were proposed to use algebra algorithms that provided means of abstract algorithm synthesis and contributed to the creation of mathematic software for visualization of graphs. Developed models provide the necessary basis for design of visualization graphs system and proposed profiles adapt chosen approach for the operation in heterogeneous environments.

Keywords: *visualization, open system, graph, unitherm, sequence, elimination.*

Introduction. The general statement of the problem. The functioning of modern data visualization systems is performed in variable conditions, in which the speed of operator response is the important factor. In particular, in the process of processes control indicated parameter is directly affecting the speed of reasoned decision-making, and therefore the quality of the final result. Therefore, the accuracy of the findings, which imposes a set of restrictions on the process of reflection and the used methods depend on the visualization time and quality of obtained image. While designing data visualization system, usually the set of technological processes appears in the form of two-dimensional data structures – graphs, which are set by using the matrix representation [1]. However, this feature of such task is the creation of set of equivalent images that are similar in structure but different in relations presentation [2]. As a result of the study on the effectiveness of graphs presentation on the plane turned out that the most effective images that meet the criteria are given in the work [3]. Namely the following is determined: uniformity of location; the minimum number of mutual intersections of arcs; inadmissibility of plane tops intersection; minimum area if generated image.

Another feature of the task of data visualization is the modern hardware as well as software, which tends to be functional integration, the hallmark of which is the union of heterogeneous information resources into a single integrated system [4]. Using this approach identified a new area of design of architecture and structure of software applications running in heterogeneous environments and implemented the concept of open systems. Ensuring the interaction between the individual elements contributed to the set of basic standards and methodologies. However, a special feature of any software created to operate in a heterogeneous environment is to respect the so-called profiles as basic tools of functional standardization [5]. In turn, the increasing complexity of such systems requires the use of additional requirements to design methods and tools. While designing such a system, it is necessary to find a solution that allows for interaction services that are governed by different operating systems, which is an extremely difficult task. Thus, the use of classical instruments does not always lead to good results, so the use a special device is proposed – algebra of algorithms [7]. This tool provides an accurate description of the algorithm, means of minimizing and optimization the number of unitherms and reduces the cost of implementing algorithms and thus research performance [8]. Given that, means of algorithms algebra were selected to create mathematic soft-ware of data visualization process in a heterogeneous environment.

Relation of highlighted issue to important scientific and practical tasks. Development of mathematic software of data visualization process is a complex scientific and practical problem, which is in the form of two sub-tasks – forming of algorithm visualization using algebra algorithms and their visualization of on the plane. Thus, the display should be in accordance with the display criteria [3] and meet the features of construction and operation in a heterogeneous environment.

These tasks are important as they directly affect both the opportunity of functioning of created software in heterogeneous environments and the quality of created graphs images. The implementation of the described issures is a complex process, in the course of which it is necessary to apply advanced unit and operations of algebra algorithms to optimize mathematic software system. The solution of the scientific and practical tasks will help standardize the process of graphs visualization with subsequent operation in heterogeneous environments and provide the necessary apparatus with known methods of adaptation to the tasks of building data visualization in accordance with the proposed profiles.

Analysis of recent research and publications. Today, while designing heterogeneous display systems, the following forms of presentation are used UML diagrams, graph models and flow charts. UML diagrams are used to describe a unified software development process and represent an open standard that uses a graphical notation to create an abstract model of the system [5]. The main purpose of the application of graph models, is a reflection of relations between the technological objects, including model evaluator that implements the functional algorithm adopted to be represented as a graph in which the tops represent function or operators of algorithm, and the arcs – dependencies on data and management [6]. Block diagrams perform the representation of the task for its analysis or solution using special characters (geometric

primitives), which represent items such as transaction flows, etc. [4]. Thus, visualization of algorithms block diagrams and UML diagrams do not cause much difficulty and provide set of software tools, including: AllFusion Process Modeler, Eclipse Modeling Framework, WizFlow Flowcharter, Umbrello UML Modeller, so graphs visualization is fundamentally different. Since this structure served to render in matrix form and does not contain information about the spatial layout. This situation promotes the appearance of set of equivalent images that are identical with structure but different in perception [9].

Known methods of visualization [2,6,10] in bulk is not designed for correct display matrix structures as: the quality perception created images and their final sizes is not consider. In addition, existing methods do not include means from the proposed unification of approaches to different types of hardware and software platforms. [11] Therefore, the actual problem is the development of mathematic software of graphs visualization process in a heterogeneous environment using algebra algorithms.

The main objectives of the study and their significance. The adaptation of software process of graphs visualization presented in the form of matrix models for the operation in a heterogeneous environment is the goal of research. The study will provide the means of constructing graph on the plane according to the known criteria of reflection and standards of open systems construction [11]. The use of open systems facilitates a possible adaptation of established software units to operate in a heterogeneous environment. To achieve this goal it is necessary to solve the following main tasks: to adapt the known methods for visualization of graphs to the problems of building cross-platform applications and algorithms to synthesize abstract arrangement of tops and even permutations for graphs "tree." Results of the study solve actual problem of mathematic software process of graphs visualization for the operation in a heterogeneous environment.

The main research results. In general, the process of graphs visualization consists of the following stages: the location of the tops on the plane, determination of distances between tops, mapping arcs between individual tops and display of identification tags. As it was shown by conducted analysis, imaging techniques and approaches towards the solution of this scientific and practical tasks, the use of methods and models proposed in the paper is appropriate [9,12]. Which from the one side implement procedures for rapid creation of optimal graph images in terms of perception, on the other hand - require the use of innovative approaches towards building software modules and their subsequent functioning in heterogeneous environment.

Location of graph tops. According to the chosen method [9.12], the choice of which depends on the type of graph that visualizes the total programming model using algebraic algorithms the sequential method that consists of two stages is performed: synthesis and elimination sequences.

Synthesis of sequences. Sequence – unitherm or formula is intended to describe linear sequences. The main elements of sequence operation are two unitherms and punctuation mark (, or ;), which is responsible for the characteristics of unitherm commutativity [6]. Given that, at the location of graph tops the introduction of the adjacency matrix (unitherm *Msum*)is held at the beginning. The next step is to identify the type of graph (unitherm *T(g)*), the image of which is formed as a result of visualization. In accordance with the identified type the coordinates of graph tops are determined (unitherm *C(Op)*) and the coordinates of the other tops in line (unitherm *C1j*). If the number of tops exceeds the number of tops of the line, the remaining tops are located in the following lines according to the type of graph and are remembered by their coordinates. At the end of work the images of located tops are displayed according to their numbers. These processes are described in the following sequence (1):

$$S1=\overbrace{\overbrace{\overbrace{T(g)\,,\,C(Op)}\,,\,C(1j)}\,,\,Pr(g)}$$
$$S2=\overbrace{\overbrace{\overbrace{T(g)\,,\,C(Op)}\,,\,C(1j)}\,,\,L4} \qquad (1)$$

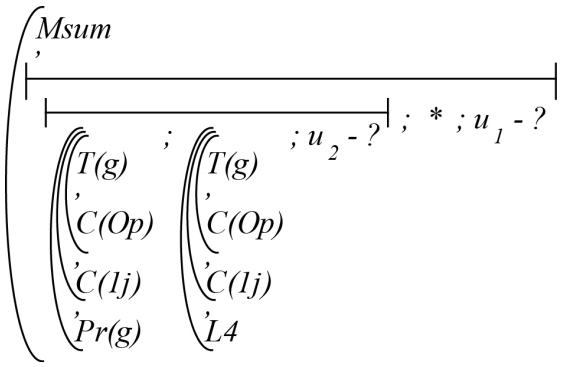
Location of tops, if it takes more than one line is described by the sequence *S3* (2):

$$S3=\left(\begin{array}{l}\left(\begin{array}{l} j=j+1 \\ , \\ C(j)\end{array}\right. \\ , \\ Pr(g)\end{array}\right. \qquad (2)$$

Synthesis elimination. Elimination – unitherm or formula of algebra algorithm for the description of branching (conditional tops) and cyclic operations [7,13]. Two unitherms and unitherm of conditions are the main elements of elimination operation. In order to describe the algorithm, the verification condition of the value of the graph is described by eliminations *L2* and *L4* (3):

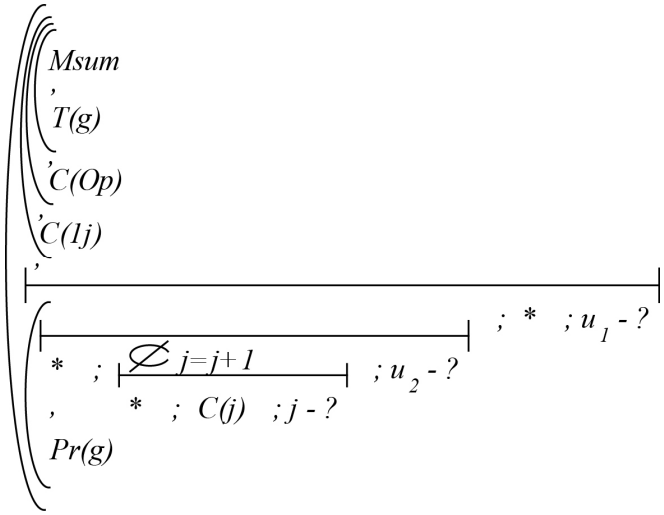
$$L2=\vdash\!\frac{\qquad}{S1\;\;;\;S2\;\;;\;u_2\text{ - ?}}\!\dashv$$
$$L4=\vdash\!\frac{\varnothing\;\; j=j+1}{Pr(g)\;\;;\;S3\;\;;\;j\text{ - ?}}\!\dashv \qquad (3)$$

After sequences substitution in the corresponding elimination the initial abstract algorithm of tops location is obtained (4):



(4)

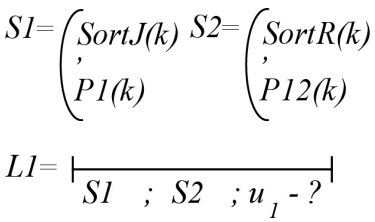
Algebra of algorithms contains means for optimization of abstract formulas of algorithms that allows performing minimization, as by the number unitherms and by moving unitherms beyond operation marks. After the optimization based on the principle of distributive, [7] unitherms are specified as marks of elimination operation, resulting in optimized abstract algorithm of tops location (5):



(5)

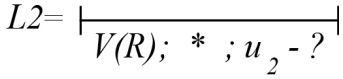
The result of the location of graph tops on the plane is a list of centers coordinates (*Xi, Yi*) and labels (*Xm, Ym*) of all tops, which are described in an abstract algorithm (5) by unitherms *C(Op), C(1j), C(j)*.

Display of connections between graph tops. After the location of tops the procedure of linkages with provision of display criteria is performed [3]. Initially, the possibility of arcs as straight is modelled and those are detected, which are mutually intersected. Next, using the method of [9] the procedure for reduction of the number of crossings is performed. Check on *k*-tier line usage is performed in sequences *S1* and *S2* and elimination *L1* (6):



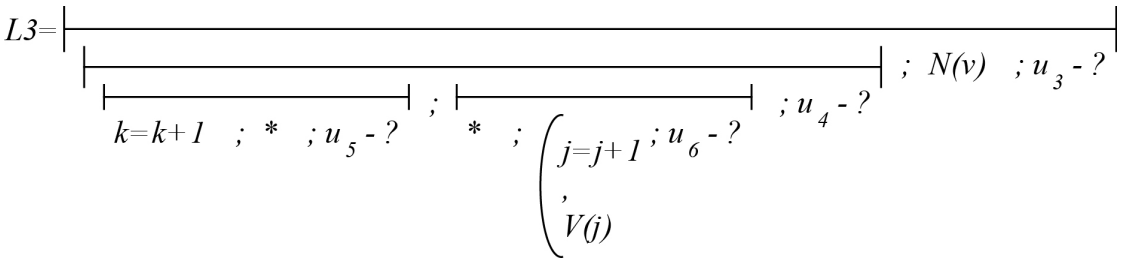
(6)

Check for increasing the number of arcs is described by elimination (7):



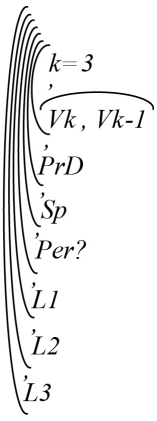
(7)

Even permutations in the graph "tree" are described by elimination *L3* (8):



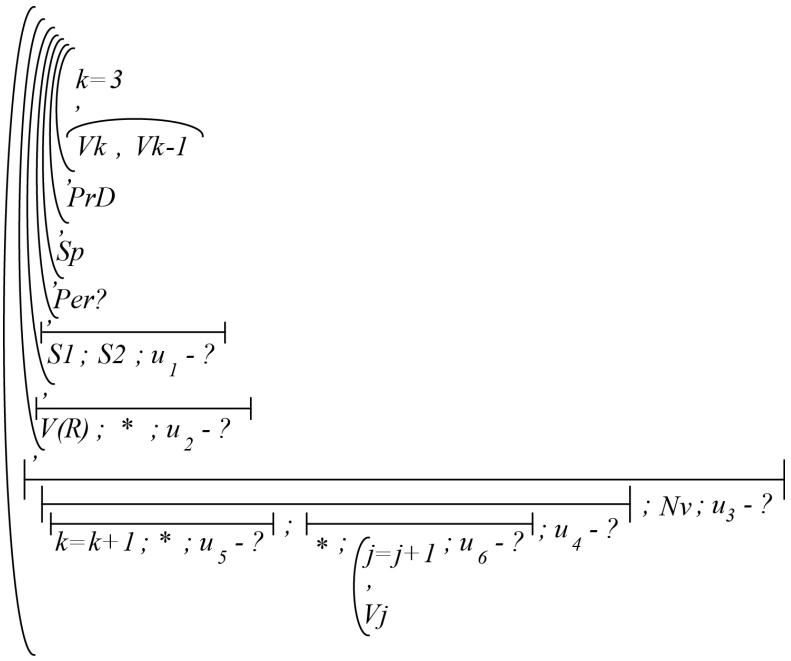
(8)

and sequence *S3* (9)*:*



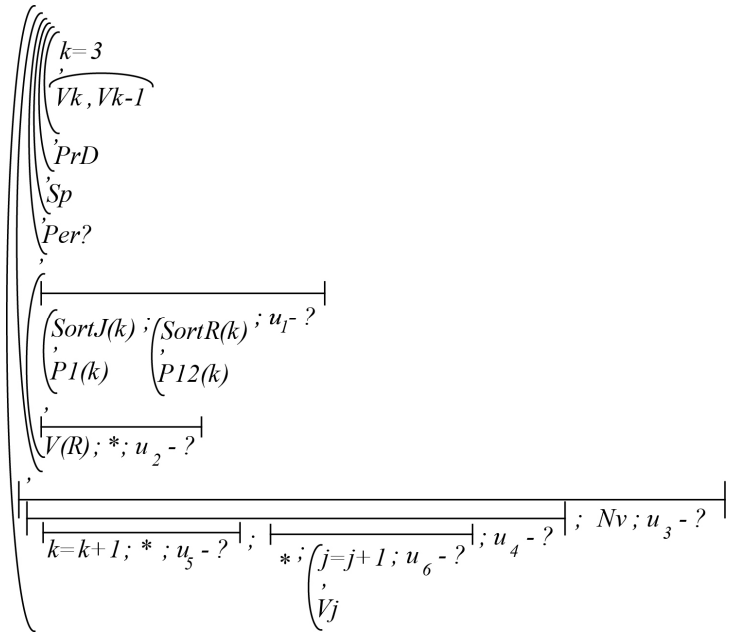
(9)

After substituting the sequences in the appropriate eliminations the initial abstract algorithm (10) of paired permutations for graphs "tree" is obtained.



(10)

After the optimization, final algorithm of paired permutations will look like (11):



(11)

As it is seen, derived formulas describe visualization tasks, namely: the location of tops and even permutations of graphs "tree". This will allow moving to mathematical models in the future by replacing the abstract unitherms by subject ones and setting sequence areas of variables and subject unitherm. That in turn based on the method of transfinite induction will allow confirming that the model describes the corresponding process [7,8].

Design of profiles. The next stage of the study was to determine profiles, with a view to creating cross-platform application in accordance with the standards of open systems. The peculiarity of the problem is that when building profile contradictory claims, in which the processes of standardization of information technology is performed should be considered. The need for development of profiles structure of graphs visualization system will provide means for its construction in accordance with the standards of open systems and provide a possible modification of preserving functional structure. However, a prerequisite for system design is the use of functional profiles: environments of imaging systems, life cycle, project infrastructure and tools.

Functional imaging system profiles consist of graphs profile components that implement the applicable system functions, and their decomposition is performed as the detail system structure. In general, the use of functional profiles is to perform such work [14]: selection of software and hardware that meet the requirements of profiles; design of application software system according to the selected profile; development of requirements for testing system components, selection or development of modular and system tests; combination of components based on consistent application of functional profiles. Regulations governing the life cycle of the graph data visualization system should be chosen depending on the characteristics of the project. In this profile the set of steps works and transactions related to the development and application profiles that specifies the design decisions should be taken into consideration. However, the iterative character development and introduction of profiles associated with the iteration of the design and maintenance of the system is an important factor. It is proposed to use an iterative approach to building described methodology of Rational Unified Process (RUP). These standards have a certain type of process frameworks that developers adapt to specific stages. To implement this class sections it is offered to use standard ISO/IEC 12207:2008 «Systems and software engineering – Software life cycle processes», which was approved in 2013.

This approach is justified because the software is much of value in creating this system, and the duration of the life cycle of software actually determines the duration of the life cycle of the system. Environment profile of visualization system determines the architecture of its building and has to be implemented in accordance with the model DCE (Distributed Computing Environment), which is supported by a consortium of OSF (Open Software Foundation) and is used as a standard, by such corporations as: Hewlett-Packard, IBM, Digital Equipment Corporation. Decomposition of functioning environment that is performed at the design stage, allows detailing the environment profile according to functional areas of benchmark model OSE/RM: graphical user interface, object-oriented database management systems, operating systems. Profile of tools determines the choice of methodology and technology creation, support and development of visualization graphs. The description of the design methodology and design decisions are made in it, and its functional part covers feature centralized management and administration related to: control performance and accuracy of the system, configuration management of applied software, configuring applications due to changes of applied functions. Usage of the described profiles provides the means for designing graph visualization system to work in a heterogeneous environment.

Conclusions. In the course of conducted study the analysis of known methods of visualization was performed that shows a lack of correct display of graphs and matrices and the use of a fundamentally new approach in the design process of cross-platform software is proposed. The synthesis of models of graphs visualization is carried out by using algebra algorithms. This approach provided means for the construction of abstract algorithms processes and display of the location of arches between them. As opposed to the classic toolkit it provides means to minimize them by the number of unitherm, synthesis and research of appropriate mathematical models. Indicated design features of graphs visualization system provide means to its further software implementation and operation in a heterogeneous environment.

Further studies will be directed to design of appropriate software units and their verification and adaptation to functioning in a heterogeneous environment, by using standard open systems.

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