Volodymyr OVSYAK [1], Oleksandr OVSYAK [2]
[1] KIELCE UNIVERSITY OF TECHNOLOGY, Al. Tysiąclecia Państwa Polskiego 7, 25-314 Kielce, Poland
UKRAINIAN UNIVERSITY OF PRINTING, Pid Goloskom 19, 79-020 Lviv, Ukraine
[2] NATIONAL UNIVERSITY OF CULTURE AND ARTS, Shuchevitsha 5, 79-020 Lviv, Ukraine

Models of layers of information systems

Prof. Ph.D. eng. Volodymyr OVSYAK

He specializes in theoretical and applied computer science, theory of algorithms, programming, information systems, mathematical modeling of systems, computer simulation and mathematical modeling. He works as an professor in Kielce University of Technology.

e-mail: ovsyak@rambler.ru

Ph.D. eng. Oleksandr OVSYAK

He specializes in theoretical and applied computer science, theory of algorithms, programming, information systems, mathematical modeling of systems, computer simulation and mathematical modeling. He works as an associate professor in National University of Culture and Arts in Lviv.

e-mail: ovsjak@ukr.net

Abstract

Model of information system layers as a scheme, algebraic expressions and computer model were created. Algebraic model of information system layers is synthesized by means of algebraic algorithms and modified systems of algorithmic algebras. A computer model of layers is created in environment Microsoft Visual Studio .NET. A four-layer model of abstract information system in the form of diagrams, mathematical formulas and models of computer system were created. Comparison of object models is performed.

Keywords: Information system layers, model of information system layers, sub-system, algorithm algebra, modified algorithmic algebra system.

Modele warstw systemów informatycznych

Streszczenie

W pracy zaprezentowano metodę uproszczenia złożoności projektowania systemu informacyjnego, polegającą na jego podziale na warstwy, z których każda zawiera jeden lub więcej podsystemów. Metoda jest oparta na wykorzystaniu zmodyfikowanego systemu algebr algorytmicznych, opracowanego przez autora [1, 2]. Przedstawiono ogólny model algebry algorytmów w postaci warstw algorytmu, który zaimplementowano w programie komputerowym. Omówiono modele warstw systemu informatycznego utworzone w postaci schematu, wykresów algebraicznych i modelu komputerowego. W programie komputerowym warstwy są reprezentowane w formie zagnieżdżonych prostokątów (rys. 8). Modele algebraiczne warstw systemu informatycznego zostały zsyntezowane przy zastosowaniu zasobów algebry algorytmów i zmodyfikowanego systemu algebr algorytmicznych (tab. 1). Model komputerowy warstw zbudowano w środowisku Microsoft Visual Studio .NET. Utworzono czteropoziomowy model warstw informatycznego systemu abstrakcyjnego w postaci schematów, wykresów matematycznych i modelu systemu komputerowego. Pokazano wyniki porównania utworzonych modeli.

Słowa kluczowe: Warstwy systemu informatycznego, model warstw systemu informatycznego, podsystem, algebra algorytmów, system algebr algorytmicznych modyfikowany.

1. Introduction

Modern information systems are complex systems. A design of information systems is a complex process. In order to simplify the design complexity the information system design is divided into layers, which may include one or more subsystems. Complexity of subsystem is significantly smaller than the complexity of the whole system. Decomposition of the layers is performed according to specific criteria. For example, the criterion can be the functionality of layers and their subsystems. There may be several layers (levels) of decomposition. For sophisticated information systems there are usually defined levels of systems, subsystems, classes, fields, methods, techniques and components.

The visual model of layers can be constructed, for example, in the form of nested rectangles.

Mathematical models of information system layers can be synthesized by known algebraic algorithms [1, 2, 3] and the system of algorithmic algebras or by modified systems of algorithmic algebras [4, 5].

Computer (simulation) model can be created in the full version of the 2012 version of the platform Microsoft Visual Studio .NET.

2. Schematic model of layers

Fig. 1 shows a schematic model of the two layer system. As it is shown in the Figure the first layer of the system (S) has n subsystems (P_0, ... P_{n-1}). Each subsystem is a layer that contains m subsystems of the second level ($Q_{0,0}$, ... $Q_{0,m-1}$, ...,$Q_{n-1,0}$, ...$Q_{n-1,m-1}$). Such decomposition of each subsystem to m subsystems is optional. Some first-level subsystems may remain undivided. They can also be divided, but each of them can have its own number of subsystems.

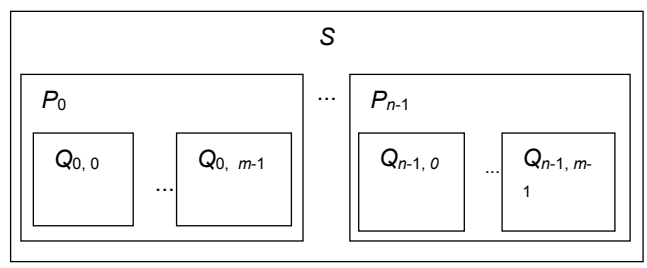

Fig. 1. General scheme of the system layers
Rys. 1. Ogólny schemat warstw systemu

In this way, one receives the model of two system layers. The first layer contains the subsystem P, and the second – subsystems Q. In the following way third and fourth layers can be created. But due to the fact that the figure for these layers is losing its visibility, then we will not make a drawing of such model construction.

3. Algebraic models of layers

3.1. Systems of operations of algebraic methods

The modified system of algorithmic algebras [5] contains a system of algorithmic algebras [4]. The system of algorithmic algebras differs of modified systems of algorithmic algebras in the presence of two additional operations. These additional operations are operations of checkpoint and synchronization. Therefore, Table 1 shows only the operation of the modified systems of algorithmic algebras [4, 5] and algebra of algorithms [1, 2, 3].

Tab. 1. Operations of algebraic methods
Tab. 1. Operacje metod algebraicznych

No	Modified system of algorithmic algebras (MSAA)		Algebra of algorithms	
	Name of operation	Operation mark	Name of operation	Operation mark
1	Conjunction	$u\&u_1$	–	
2	Disjunction	$u_1\beta$	–	
3	No	$\overline{u}$	No (reverse)	$\overline{u}$
4	Forecasting	$X\bullet\alpha$	–	
5	Composition	$X*Y$	Sequencing	$\overline{X;Y}$
6	Alternative	$([\alpha]\ X,\ Y)$	Elimination	$\overline{X;Y;u}$
7	Cycle	$\{[\alpha]\ X\}$	Cycle sequencing	$\not\subset u\ X$
8	–		Cycle elimination	$\not\supset u\ X$
9	–		Cycle paralleling	$\not\emptyset u\ X$
10	Filtration	$F(\alpha)$	–	
11	Asynchronous disjunction	$X\|\|Y$	Paralleling	$\overline{X;Y}$
12	Control point	$T(\alpha)$	–	
13	Synchronization	$S(\alpha)$	–	

Dash ("-") in Table 1 means no operation

3.2. Model of algebra of algorithm layers

Model system (S) is divided in the first level to the subsystems (P) and is described using cyclic operation of paralleling ($\not\emptyset$) and is as follows: $S= \not\emptyset i P_i$, where: S – system; P_i – subsystem of the first level of decomposition; i – variables of first level of decomposition, $i \in \overline{0, 1, \ldots p\text{-}1}$; p – maximum value of variable of first level.

The model of the second layer of subsystem decomposition of the first level is shown in the formula: $P_i= \not\emptyset j_i Q_{j,i}$, where: $Q_{j,i}$ – subsystem of the second level of decomposition; j – variables of second level of decomposition, $j \in \overline{0, 1, \ldots q\text{-}1}$; q – maximum value of variable of second level.

Third level of decomposition: $Q_{j,i}= \not\emptyset t_{j,i} F_{t,j,i}$, where: $F_{t,j,i}$ – subsystem of the third of decomposition; t – variables of third level of decomposition, $t \in \overline{0, 1, \ldots s\text{-}1}$; s – maximum value of variable of third level.

The fourth layer of partitioning is the following formula of algebra of algorithms: $F_{t,j,i}= \not\emptyset x_{t,j,i} H_{x,t,j,i}$, where: $H_{x,t,j,i}$ – subsystem of the fourth of decomposition; x – variables of fourth levels of decomposition, $x \in \overline{0, 1, \ldots h\text{-}1}$; h – maximum value of variable of fourth level.

The general formula of the model layers is as follows:

$$S= \not\emptyset i P_i= \not\emptyset i \not\emptyset j_i Q_{j,i}= \not\emptyset i \not\emptyset j_i \not\emptyset t_{j,i} F_{t,j,i}= \not\emptyset i \not\emptyset j_i \not\emptyset t_{j,i} \not\emptyset x_{t,j,i} H_{x,t,j,i}. \quad (1)$$

3.3. Layer model presented by modified system of algorithmic algebras

Layer models of first, second, third and fourth levels, described by means of the modified system of algorithmic algebras are expressed, respectively, by the following formulae:

$$\begin{aligned} S &= P_0 \,\|\, P_1 \,\|\, \ldots P_{p\text{-}1}\,, \\ P_i &= Q_{0,\,i} \,\|\, Q_{1,\,i} \,\|\, \ldots\, Q_{q\text{-}1,\,i}\,, \\ Q_{j,i} &= F_{0,\,j,\,i} \,\|\, F_{1,\,j,\,i} \,\|\, \ldots\, F_{s\text{-}1,\,j,\,i}\,, \\ F_{t,j,i} &= H_{0,\,t,\,j,\,i} \,\|\, H_{1,\,t,\,j,\,i} \,\|\, \ldots\, H_{h\text{-}1,\,t,\,j,\,i}. \end{aligned}$$

The general formula of the layer model is as follows:

$$\begin{aligned} S= (P_0 = (Q_{0,0} =& (F_{0,0,0}= (H_{0,0,0,0}\| \ldots H_{h\text{-}1,0,0,0})\| \ldots F_{s\text{-}1,0,0}= \\ & (H_{0,s\text{-}1,0,0}\| \ldots H_{h\text{-}1,s\text{-}1,0,0}))\| \ldots \\ Q_{q\text{-}1,0} =& (F_{0,\,q\text{-}1,0}= (H_{0,0,\,q\text{-}1,0}\| \ldots H_{h\text{-}1,0,\,q\text{-}1,0})\| \ldots F_{s\text{-}1,\,q\text{-}1,0}= \\ & (H_{0,s\text{-}1,\,q\text{-}1,0}\| \ldots H_{h\text{-}1,s\text{-}1,\,q\text{-}1,0})))\| \ldots \\ (P_{p\text{-}1} = (Q_{0,\,p\text{-}1} =& (F_{0,0,\,p\text{-}1}= (H_{0,0,0,\,p\text{-}1}\| \ldots H_{h\text{-}1,0,0,\,p\text{-}1})\| \ldots F_{s\text{-}1,0,\,p\text{-}1}= \\ & (H_{0,s\text{-}1,0,\,p\text{-}1}\| \ldots H_{h\text{-}1,s\text{-}1,0,\,p\text{-}1}))\| \ldots \\ Q_{q\text{-}1,\,p\text{-}1} =& (F_{0,\,q\text{-}1,\,p\text{-}1}= (H_{0,0,\,q\text{-}1,\,p\text{-}1}\| \ldots H_{h\text{-}1,0,\,q\text{-}1,\,p\text{-}1})\| \ldots F_{s\text{-}1,\,q\text{-}1,\,p\text{-}1}= \\ & (H_{0,s\text{-}1,\,q\text{-}1,\,p\text{-}1}\| \ldots H_{h\text{-}1,s\text{-}1,\,q\text{-}1,\,p\text{-}1})))). \end{aligned} \quad (2)$$

3.4. Computer layer model

Part of the main window of environment of Microsoft Visual Studio .NET is shown in Fig. 2. It contains an option ARCHITECTURE. The choice of this option provides a submenu New Diagram. After activating this submenu the window appears, shown in Fig. 3.

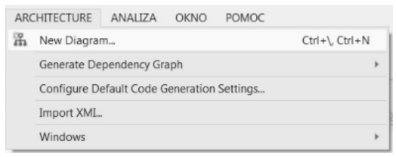

Fig. 2. Part of the main window
Rys. 2. Fragment okna głównego

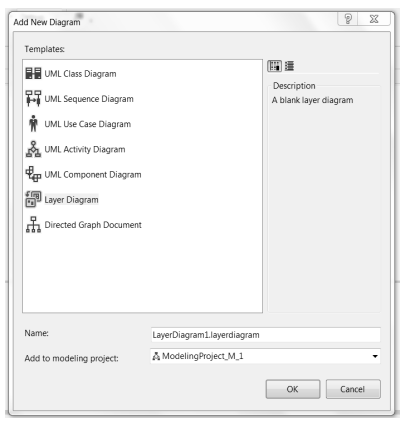

Fig. 3. Window with the Layer Diagram option
Rys. 3. Okno z opcją Layer Diagram

By this window is possible to select the option Layer Diagram. After choosing it the window with tools to build a layer chart appears (Fig. 4).

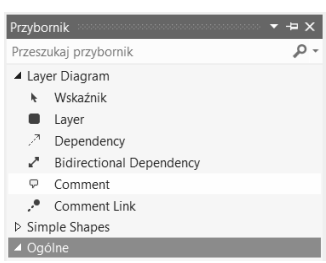

Fig. 4. Tools to build a diagram of layers
Rys. 4. Narzędzia do budowania diagramu warstw

Selection and dragging the Layer tool provides the possibility to form a layer in the shape of painted rectangle (Fig. 5). After its activation the screen with additional options appears (Fig. 5). Selecting the option "Właściwości" (features) the new window appears (Fig. 6).

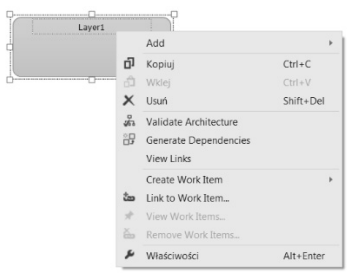

Fig. 5. Possibilities of pop-up window
Rys. 5. Możliwości do wyboru w wywołanym oknie

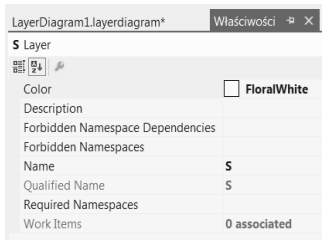

Fig. 6. Properties of window Features (Właściwości)
Rys. 6. Opcje okna Właściwości (Features)

In the window 6, one can specify the name of the layer and its components.

With the use of the tools of Microsoft Visual Studio .NET one primarily forms a rectangle and names it *S*. Now we enter the rectangles with the names P_0, P_1, ... P_{p-1}. They are subsystems of *S* and form the first layer of the system (Fig. 7).

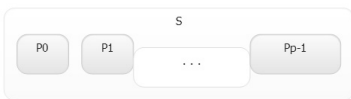

Fig. 7. First layer of the system
Rys. 7. Pierwsza warstwa systemu

Next we can create the components of the second layer in the same way, they are following $Q_{0,0}$, $Q_{0,1}$, … $Q_{0,q-1}$ for P_0; $Q_{1,0}$, $Q_{1,1}$, … $Q_{1,q-1}$ – for $P1$ and $Q_{p-1,0}$, $Q_{p-1,1}$, … $Q_{p-1,q-1}$ – for P_{p-1}. Later are created the components of the third layer in the similar way ($F_{0,0,0}$, $F_{0,0,1}$, … $F_{0,0,f-1}$ – for $Q_{0,0}$; $F_{0,1,0}$, $F_{0,1,1}$, … $F_{0,1,f-1}$ – for $Q_{0,1}$; … $F_{p-1,q-1,0}$, $F_{p-1,q-1,1}$, … $F_{p-1,q-1,f-1}$ – for $Q_{p-1,q-1}$) and of the fourth ($H_{0,0,0,0}$, $H_{0,0,0,1}$, … $H_{0,0,0,h-1}$ – for $F_{0,0,0}$; $H_{0,0,1,0}$, $H_{0,0,1,1}$, … $H_{0,0,1,h-1}$ – for $F_{0,0,1}$; … $F_{p-1,q-1,f-1,0}$, $F_{p-1,q-1,f-1,1}$, … $F_{p-1,q-1,f-1,h-1}$ – for $F_{0,1,f-1}$) layers. Partially created model is shown in Fig. 8.

4. Comparison of layer models

Schematic layer model in comparison to verbal model is more clear and compact, and easier to understand. It is useful for relatively small amounts of horizontal and vertical layers. Each layer is formed by certain number of subsystems, formed by division of the system. The layers of one level of decomposition form horizontal layers. Layers of different levels of decomposition form vertical (nested) layers. Schematic layer model can be created using universal computer systems, for example, Microsoft Visual Studio .NET. If the number of layers of schematic model achieves a dozen or more layers, then this model ceases to be a clear and compact and easy to understand.

Algebraic layer models are less perspicuous than the schematic model. However, they are more compact than schematic model. In algebraic models abstract mathematical tool is applied. In this respect, they are more difficult for synthesizing and perception.

The presence of a cyclic operations of paralleling in algorithm algebra provides more compact model than the use of algorithmic algebras or its modifications. Also cyclic operation of paralleling can be used for presentation not only of associative and commutative but also of non-commutative and non- associative models of layers, while the system of algorithmic algebras and its modifications can be used to describe only associative and commutative models of layers. This is due to the presence in operation of asynchronous disjunction of associative and commutative properties.

Synthesis of algebraic models can be carried out using known Universal Computer Systems, in particular, such as Microsoft Visual Studio .NET. However, for the synthesis of computer layer model by means of algorithm algebra is the most effective use of specialized editors. Known specialized editors are "MODAL", "ABSTRAKTAL" and "SOFAL" [3]. Editor "SOFAL" has the largest flexibility in comparison with the "MODAL" and "ABSTRAKTAL." Therefore, the most appropriate is the Editor "SOFAL".

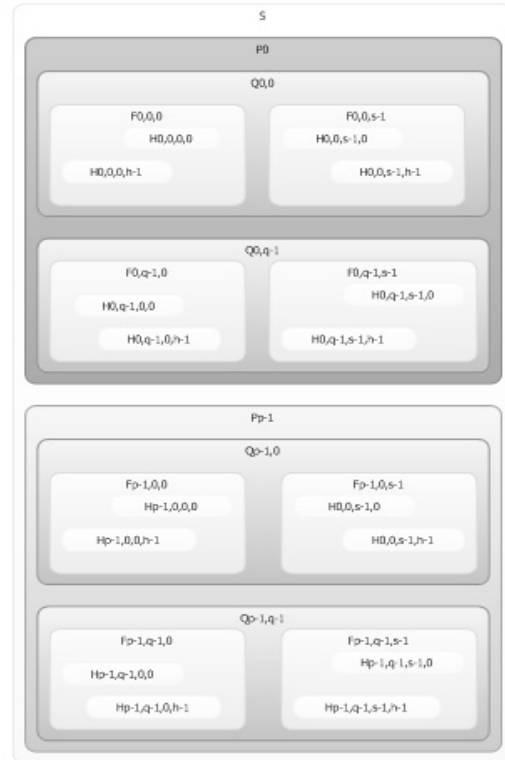

Fig. 8. Computer model of layers
Rys. 8. Komputerowy model warstw

Highly automated process of synthesis of models of layers is the use of the platform Microsoft Visual Studio .NET 2012. By means of these specialized facilities, the layers of the model can be quite easily built. Such models are transparent and easy for perception. But they are effective only for a relatively small number of horizontal and vertical layers. However, when there are more than a dozen layers this model ceases to be clear and easy to understand. In such cases, the algebraic layer model is absolutely advantageous.

5. Conclusions

Model of layers that are synthesized in an environment Microsoft Visual Studio .NET 2012 for a relatively small number of layers are transparent, easy to perceive and are received by a small cost of labor and time.

The most compact model of layers is the algebraic model. The most compact model is synthesized by the use the algorithm algebra. In addition, with the help of algorithm algebra, if necessary, can be described non-commutative and non-associative layer models. They cannot be obtained by other well-known algebraic methods.

6. References

[1] Owsiak W., Owsiak A., Owsiak J.: Teoria algorytmów abstrakcyjnych i modelowanie matematyczne systemów informacyjnych. Wyd. Pol. Opolskiej, Opole, 2005.
[2] Owsiak W., Owsiak A.: Rozszrzerzenie algebry algorytmów. Pomiary, Automatyka Kontrola, vol. 56, No 2, 2010, pp.184-188.
[3] Ovsyak O., Ovsyak V.: Modificirovannaja algebra algoritmov i instrumentalnyje sredstwa obrabotki formul algorytmov. Upravlajuszczije systemy i masziny. No 1, 2013, pp. 27 – 36.
[4] Gluschkow W.M., Zeitlin G.E., Justchenko J.L.: Algebra. Sprachen. Programmierung. – Akademie-Verlag, Berlin 1980. – 340 p.
[5] Cejtlin G.E.: Algebraiczeskaja algorytmika: teoria i primenenija. Kibernetika i sistemnyj analiz. No 1, 2003, pp. 8 – 18.

otrzymano / received: 10.03.2014
przyjęto do druku / accepted: 02.05.2014 *artykuł recenzowany / revised paper*