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MODELLING BALANCED CRITERIA SYSTEM FOR BUSINESS PROCESS MANAGEMENT

Modelagem de sistema de critérios equilibrados para gestão de processos de negócios

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ABSTRACT

The research aims at developing a fundamental technique for modelling balanced criteria system necessary to create encapsulations, within unified network protocols, to monitor every existing change in the business process or create their simulations (inheritance) and polymorphism in business process management. The research topicality is related to the description of modern transformations concerning the modelling of business processes associated with the data deepening with the need to adapt them to object-oriented programming in order to automate management. Therefore, there is an ongoing introduction and use of complex formats of network presentation of data with a unified language, which: balance the basic criteria of each “workflow” (based on systemic improvement of methods and tools for modelling workflows, their efficient and fast processing); maximize their benefits for the implementation of optimization solutions. In the process of designing the technique we used the methods of network modelling, network theory, which are aimed at solving problems of balancing the criteria of business process management. The process of network modelling with a unified language is implemented in the research, which is focused on the production of balance in the systems of business process management criteria. Basic attention is paid to the transition from analytical search of balance according to the workflow criteria to a graphic one. The proposed technique of modelling balanced criteria system for business process management is focused on large data volumes, so its basic processes were implemented using cloud computing service — math.semestr. The obtained results allow to form systems of balanced criteria, which are easily perceived in business process management and are effective in the conditions of continuous growth and distribution of information on numerous nodes of workflows. The proposed approach to modelling the system of balanced criteria of business process management is promising in terms of automation of business process management.

Keywords: Programming; Workflow; Time reserve; Work time; Balance.

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MODELAGEM DE SISTEMA DE CRITÉRIOS EQUILIBRADOS PARA GESTÃO DE PROCESSOS DE NEGÓCIOS

Modelling balanced criteria system for business process management

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RESUMO

A pesquisa teve como objetivo desenvolver uma técnica fundamental para modelagem de sistemas de critérios balanceados necessários para criar encapsulamentos, dentro de protocolos de rede unificados, para monitorar todas as mudanças existentes no processo de negócio ou criar suas simulações (herança) e polimorfismo na gestão de processos de negócio. A atualidade da pesquisa está relacionada à descrição das transformações modernas no que diz respeito à modelagem de processos de negócios associada ao aprofundamento de dados com a necessidade de adaptá-los à programação orientada a objetos para automatizar o gerenciamento. Portanto, há uma contínua introdução e uso de formatos complexos de apresentação de dados em rede com uma linguagem unificada, que: equilibram os critérios básicos de cada "workflow" (com base no aprimoramento sistêmico de métodos e ferramentas de modelagem de workflows, seus eficientes e rápidos em processamento); maximizar seus benefícios para a implementação de soluções de otimização. No processo de concepção da técnica foram utilizados os métodos de modelagem de redes, teoria de redes, que visam resolver problemas de balanceamento de critérios de gestão de processos de negócios. O processo de modelagem de redes com uma linguagem unificada é implementado na pesquisa, que tem como foco a produção de equilíbrio nos sistemas de critérios de gestão de processos de negócios. Atenção básica é dada à transição da busca analítica de equilíbrio de acordo com os critérios do fluxo de trabalho para uma busca gráfica. A técnica proposta de modelagem de sistema de critérios balanceados para gerenciamento de processos de negócios é focada em grandes volumes de dados, portanto seus processos básicos foram implementados utilizando o serviço de computação em nuvem - math.semestr. Os resultados obtidos permitem formar sistemas de critérios equilibrados, facilmente percebidos na gestão dos processos de negócio e eficazes nas condições de crescimento contínuo e distribuição de informação em inúmeros nós de workflows. A abordagem proposta para modelar o sistema de critérios balanceados de gestão de processos de negócios é promissora em termos de automação da gestão de processos de negócios.
Palavras-chave: Programação; Fluxo de trabalho; Reserva de tempo; Tempo de trabalho; Equilíbrio

INTRODUCTION

Topicality. Due to the continuous increase in the volume of information in the contexts of business process identification, design, documentation and control of their components, management in this area is under constant transformational changes due to data deepening. This affects such basic planes as: efficiency, cost, quality, time etc. Any business process is a network with multi-level hierarchical workflows that move from one employee to another, and for large business processes — from one department to another. Optimizing a specific business process (in particular, in terms of basic criteria — performance, cost, quality, time) always produces the opposite effects on workflows. When one flow parameter improves, the other deteriorates. For example, reducing the time of a business process increases its cost and degrades its quality, and improving the quality of a business process leads to an increase in its cost and duration criteria. Therefore, when deciding on the choice of business process, it is advisable to focus on the model and consider not only the impact of time of developed options on workflows, but also the impact of their cost and quality (the content of which is individual).

From the beginning of the 20th century such methods as the choice of a business process option according to the scheme, functional flow block diagram, control scheme, IDEF and PERT were used for fragmentary modelling of business processes(Booch; Rambeau; Jacobson, 2000) Gantt charts were used among the first in 1900 (Komar, 2007), functional flowchart and PERT — in the 1950's, data flow and IDEF charts — in the 1970's (Taranyuk, 2016).

Modern transformations of business process modelling are associated with data deepening with the need to adapt them to object-oriented programming in order to automate management (Chorna, 201). Therefore, there is an ongoing introduction and use of complex formats of network presentation of data with a unified language, which: balance the basic criteria of each workflow (based on systemic improvement of methods and tools for modelling workflows, their efficient and fast processing); maximize their benefits for the implementation of optimization solutions (Taranyuk, 2016).

The desire to automate management requires not just a theoretical description of the principles of each business process, but encapsulation, within the creation of a set of unified network protocols that interact with each other to monitor every existing change in the business process or create their simulations (inheritance) for the purpose of timely balancing of basic criteria, considering their multidirectional action (Krivoruchko, 2018). This is necessary to create a polymorphism (concept for programming) in business process management.

Aim and objectives (scientific questions). Therefore, this research aims at developing a fundamental technique for modelling balanced criteria system needed to create encapsulations, within unified network protocols, to monitor every existing change in the business process or create their simulations (inheritance) and polymorphism in business process management. In accordance with the aim, the objectives of the study are the following: 1) determine the content and features of balance production in the systems of business process management criteria that reflect the content of all workflows; 2) determine and describe procedures and methods of network modelling, which is focused on the production of balance in all systems of criteria for business process management; 3) testing of the method of modelling balanced criteria system and determining a convenient tool to illustrate its results.

CRITICAL LITERATURE REVIEW

Analysis of modern approaches to business process management, focused on the practice of modelling their criteria of the largest Ukrainian retail company, and review of research by scientists dealing with these issues allow us to state that this area is characterized by processes of gradual transition from fragmentary modelling of workflows, their inherent actions (related to past changes) to formalize all the basic criteria in complex network models with a unified presentation language. Their inherent actions (related to past changes) to formalization of all the basic criteria in complex network models with a unified presentation language. In particular, Iqbal MF, Zahid, Habib, John based business process management on network traffic forecasting using real-time applications (2019). Maita, Martins, Paz, Peres for business process management proposed the process of mining efficiency, quality and optimality of each workflow (2016).

To this end, domestic scholars also offer techniques that support the application in object-oriented programming, namely:

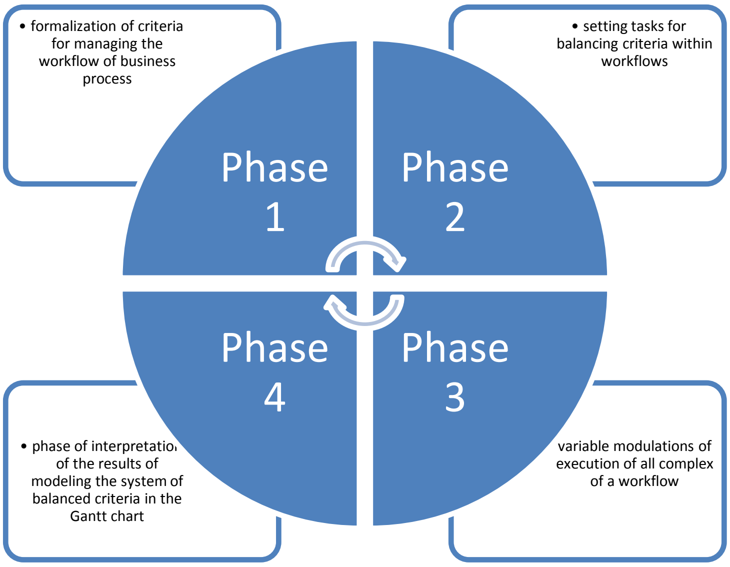
- functional modelling, which allows depicting and analysing their structure and relationships with the help of visual graphic language and network graphs of workflows within the system (Z.M.Hadetska, M.O.Kholopova);
- criterion network modelling of business process quality, which allows assessing the efficiency, quality and optimality of each workflow on the business process in real time (Komar, 2007);
- models of "network black box", which allows compiling maps of business processes, which regulate and specify the list and nature of its resources (inputs), determine the specification of its results (outputs) (Glushchevaky, 2015);
- graph of business process modelling, which allows representing a business process as an abstract mathematical object, and a separate workflow as a set of graph vertices and a set of edges (Chorna, 2011).

However, the problem of business process management of economic entities is due to the lack of information as to the basic criteria. Any business process (hereinafter — "the BP") is characterized not only by time, cost, result and quality, but also fragmentation (namely the number of employees and departments involved) (Masligan, 2020). The modelling technique is needed, which forms a model set of operations for manipulating data networks in the system of business process management criteria (efficiency, cost, quality, time, fragmentation), while forming a set of routines to find the balance.

THEORY AND METHODOLOGY

To model a system of balanced criteria for business process management, a research model based on classical network models with a unified modelling language, which is an integral part of software development, was used. This research model (or research procedure) is formed on the basis of an illustrative model description, implemented in the form of a list of performed operations, indicating their relationship in the mathematical table. Such modelling affects a finite set of given rules, which are generalized within 4 phases (Figure 1).

Figure 1 Research model or research procedure for modelling balanced criteria system for business process management



Note / * phase 1 (formed on the basis of the most important indicators of the model for balancing, including: efficiency, cost, quality and time, fragmentation); phase 2 (formed according to a particular business process; phase 3 (variable modulations of the workflow for d days according to the unified parameters of the network model, which are time reserves of each path (or workflow); private time reserve of the first type; private time reserve of the second type; free time reserve; independent time reserve); phase 4 (the diagram is used to illustrate the current state of the real system, according to the work performance parameters).

Such a network model of BP determines the research procedures that involve the formation of tabular-graphical representation of a set of works (in particular, their illustrative model description), consisting of threads (works) and nodes (events), which depict the entire logical relationship of operations.

ATB was chosen as the object of the study, as it was necessary to comprehensively illustrate the current state of the real system according to the work parameters. The company was chosen due to the fact that it is not only the most dynamically developing in Ukraine, but is the only large domestic company that has developed and implemented business process regulations. In addition, the management of the chain of stores is considering the feasibility of implementing the practice of modelling balanced criteria system for managing retail business processes.

The research model is based on the following tools:

1) network modelling. The tools are aimed at solving the problems of balancing the business process management criteria through network description of workflows in the system of criteria;

2) variable modelling. The tools are aimed at creating modulations of the workflow for d days, according to the content of the unified parameters of the network model, including the timing of the event, start of the work, its completion, time reserves and the duration of the critical path;

3) network illustration of the plan or schedule for all workflows. Given the complexity of modelling, its basic processes were implemented using cloud calculations — math.semestr. The procedures are described in order to provide high illustrativeness of the basic modelling processes. A typical sample of the business process of retail sales was used for the formation of the sample population in relation to the workflows.

In this study, the basis for formalizing the criteria for managing the workflow of the business process is the workflow of the Retail Department of ATB, selected data on all workflows that characterize such a business process of retail sales. In particular: 1 - purchase of raw materials and supplies; 2 - purchase of goods for resale; 3 - support for uniform prices in the retail network; 4 - production of own goods; 5 - control over the execution of orders; 6 - introduction of adequate information systems; 7 - marketing and space management on the shelves; 8 - range management; 9 - merchandising; 10 - customer service at the checkout.

To formalize the basic criteria for managing the flow of business process of retail sales of the Company we used data from the system of ATB’s regulations, in particular data on all workflows of the retail department (performance indicators (i,j)), work duration (t_{ij}), which is specified by two estimates - the minimum (t_{min}(i,j)) and maximum (t_{max}(i,j)) number of previous works. The minimum estimate t_{min}(i,j) characterizes the duration of work under the most favourable conditions, and the maximum t_{max}(i,j) — under the most unfavourable conditions. Work duration (t_{ij}) is considered by the Retail Department of ATB as a random variable, which can take any value in a given interval as a result of realization. Algorithms for formalizing the basic criteria for the BP workflow management of ATB’s retail sales are outlined in Annex A.

Formalization of the basic criteria for managing the BP workflow of the Company’s retail sales business process is launched in math.semestr by the function of “network model analysis-visualization”. Balancing of the outlined basic criteria is carried out according to the algorithms of network diagram optimization according to the parameter “reserves-cost” (Table 1), which provide for the calculation of the cost of work acceleration (UAH/day), h(i, j) to calculate the reduction of the unit cost of work, ΔC_{ij} and basic characteristics of the BP model.

Table 1 Algorithms for optimizing the network diagram for the parameter "reserves-cost"

Optimization criterion	Workflow management criteria	Algorithm	Main designation	Use of the obtained data
Reduction of the unit cost of works, ΔC_{ij}	determines the cost of the optimized BP	R_{ij}^{C1}* h(i,j)	Free reserve R_{ij}^{C1} Coefficient of costs for acceleration of works (UAH / day), h(i,j)	Basic characteristics of the model, in particular: the cost of a balanced workflow, the complexity of the network diagram, intensity rates
cost of a balanced workflow	the cost of the optimized workflow of the BP	$C_1 = C - \Delta C$	reduction of the unit cost of the wors of the BP, $\Delta C_{ij;\,C}$ - specific cost of the works of the BP	
Complexity factor	Network diagram complexity*	$K_c = n_{pab} / n_{cob}$	npab - number of works, units; ncob - number of events, units	
Work ntensity rate Pi, j	is the ratio of the duration of non-converging (falling between the same events) segments of the path, one of which is the path of maximum duration passing through this work, and the other - the critical path **	$KH = \frac{t(Lmax) - t1cr}{tcr - t1cr}$	t (Lmax) - duration of the maximum path passing through the work Pi, j, from the beginning to the end of the network diagram; tcr - duration of the critical path; t1cr - duration of the segment of the considered maximum path that coincides with the critical path.	
Probability of performing the whole set of works Z	estimation of probability of performance of all complex of works within the minimum term	$Z=(T-T_{crp})/S_{cr}$	Z - normative deviation of a random variable, Scr - the variance of the critical path, the standard deviation, which is calculated as the square root of the variance of the duration of the critical path.	

***** Network diagrams with a complexity factor from 1.0 to 1.5 are simple, from 1.51 to 2.0 - medium complexity, more than 2.1 - complex.
****** Work intensity rate Pi, jcan vary from 0 (for works in which the segments of the maximum of the paths that do not coincide with the critical path, consist of fictitious works of zero duration) to 1 (for works of the critical path). The closer to 1 the work intensity rate Pi,j, the more difficult it is to perform this work in a timely manner. The closer the work intensity rate Pi, j to zero, the greater the relative reserve of the maximum path passing through this work.

Algorithms for formalizing additional criteria for managing the workflow of the ATB's business process of retail sales were used to adjust the time reserve considering the reorientation of the criteria in the table of Annex A to additional parameters of the BP workflow to optimize labour resources. The need for labor resources is equalized while minimizing the number of simultaneously employed performers. Most of the additional workflow management criteria are similar to those in the table in Annex A, except for the time reserve R(i), for which the late and early deadlines are adjusted according to the number of performers. Thus, the system of cloud calculations math.semestr adjusts R(i) by selecting the minimum (according to the current regulations of the BP of ATB) terms of events (from the permissible ones, if it is possible to perform all subsequent work on time by a given number of performers).

The basic research method is a network illustration, implemented using a Gantt chart, which is graphical dices placed on a horizontal time scale. The math.semestr automatically fills in the Data Entry list and starts the Distance Matrix analysis (if the number of vertices is specified). The diagram is used in parallel with the table with the list of works, the rows of the diagram correspond to the separate task shown on the diagram, and columns contain additional information on the task.

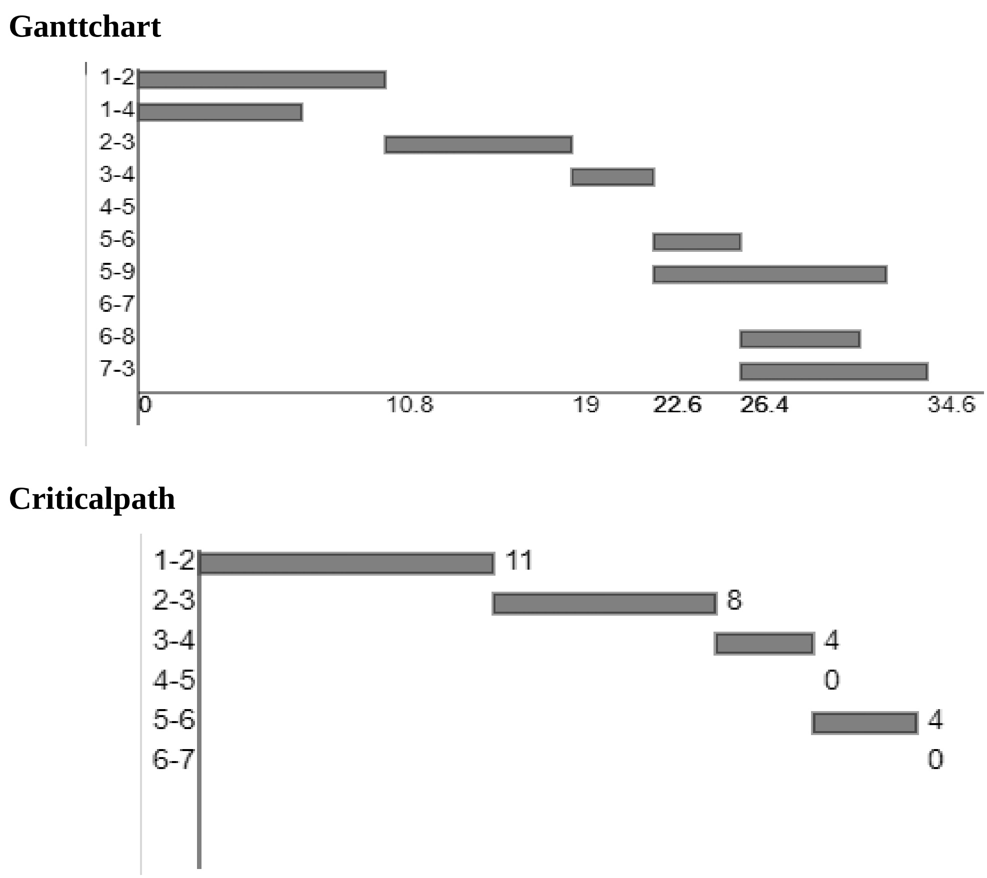
RESULT AND DISCUSSION

We realized the process of network modelling with a unified language according to the procedures focused on the production of balance in the systems of business process management criteria. The author's presentation of the results of network modelling is realized using a Gantt chart.

Gantt chart is the final expression of the current state of the real system or business process, according to the parameters of the work belonging to such a business process (Figure 2). The result allows us to clearly illustrate the nature of the balance and the balancing map of the basic criteria (performance, cost, quality, time, and fragmentation) for the workflows of the business process of the retail department of ATB. In fact, the balancing map is one of the simplest means of interpreting the results of modelling balanced criteria system of the business process and their presentation with the already existing real systems of ATB.

The Gantt chart is ideal for illustrating the current state of the real system according to the work parameters. The part of the rectangle corresponding to the task is shaded, noting the percentage of completion of the task as to balancing basic criteria.

Figure2 Gantt chart and balancing map of basic criteria for the workflow of the business process of the Retail Department of ATB



Source:generated in math.semestr according to the data of ATB and the data of Annexes B, C and Table. 2.

Table 2 Additional systems of criteria for managing the workflow of business process of the Retail Department of ATB (according to Annexes A, B and Table 1)

Options for achieving a balance by the number of performers (calculation according to Table 1, but the late and early deadlines are adjusted according to the minimum possible number of performers)										Parameters of additional balancing by number of performers[2]		
Work (i,j)1	Duration t_{ij1}	Early term[2]		Late term[2]		Time reserves		Private reserve		Number of performers[2]	Time reserve$t^{р}(i)$- $t_{i\text{-}j}$ -$t^{п}(i)$	Time reserve adjustmentR(i)asR(i) Table 3- R(i) Table 5.
		start$t_{ij}^{Р.Н.}$	completion$t_{ij}^{Р.О.}$	start$t_{ij}^{П.Н.}$	completion$t_{ij}^{П.О.}$	full$R_{ij}^{П}$	independentR_{ij}^{i}	Type I, R_{ij}^{1}	Type II, R_{ij}^{C}			
...	10.8	...	...	-10.8	0	-10.8	0	-10.8	0	2	0	-
...	7.2	...	...	19	26.2	19	15.4	19	15.4	3	-10.8	-
...	8.2	10.8	19	-8.2	0	-19	10.8	-8.2	0	8	-19	-
...	3.6	19	22.6	22.6	26.2	3.6	19	22.6	0	11	-22.6	3.6
...	8.2	19	27.2	-8.2	0	-27.2	19	-8.2	0	4	-22.6	3.6
...	0	22.6	22.6	26.2	26.2	3.6	-3.6	0	0	5	-26.4	4.8
...	3.8	22.6	26.4	27.4	31.2	4.8	-3.6	1.2	0	5	-26.4	-27.2
...	10.2	22.6	32.8	26.2	36.4	3.6	-3.6	3.55	0	2	4	4.8
...	5.2	26.4	31.6	31.2	36.4	4.8	-4.8	0	0	7	2.8	3.6
...	11.6	27.2	38.8	-11.6	0	-38.8	-15.2	-11.6	-42.4	9	0	0
...	9.2	27.2	36.4	27.2	36.4	0	27.2	27.2	0			
...	0	31.6	31.6	36.4	36.4	4.8	-3.6	0	1.2			
...	0	32.8	32.8	36.4	36.4	3.6	0	0	3.6			

1 corresponds to the values of the column “work” in table of Annex B
2 new data are determined by the content of the regulations of the BP of the retail sales of ATB
Source: generated in math.semestr according to the Retail Department of ATB

You can also add a vertical line on the workflow (1 - purchase of raw materials and supplies; 2 - purchase of goods for resale; 3 - support for uniform prices in the retail network; 4 - production of own goods; 5 - control over the execution of orders; 6 - introduction of adequate information systems; 7 - marketing and space management on the shelves; 8 - range management; 9 - merchandising; 10 - customer service at the checkout), which corresponds to the moment of “today”).

The Gantt chart and the balancing map of the basic criteria for the workflows of the business process of the Retail Department of ATB is formed as a result of consistent application of the network modelling procedure, focused on the production of balance in all systems of business process management criteria.

The procedure of network modelling with a unified language is designed to provide an illustrative model description in the form of a list of performed workflows with respect to their relationship with such unified parameters of operations as (Francescomarino, Ghidini, Maggi, Milani, 2018):

- early completion of the event;
- late completion of the event;
- early work start date;
- early work completion date;
- late work start date;
- late work completion date;
- time reserve for the event (which controls the quality of work);
- full time reserve;
- free time reserve;
- duration of the critical path.

The outlined content of network modelling procedures with a unified language is focused on the production of balance in all systems of criteria for business process management, unified parameters of operations necessitated the introduction of the following indicators of the network model:

- time reserves of each path (or workflow), which determine the possibilities of the balance of criteria, illustrating the reserve to increase the duration of this path without compromising the onset;
- private time reserve of the first type R1;
- private time reserve of the second type of work Rc(i,j) — determines the part of the total time reserve by which you can increase the duration of work without changing the early date of its final event;
- free reserve of working time — indicates the location of reserves necessary to achieve a full balance of all criteria important for workflow management;
- independent time reserve of work Ri(i, j).

These indicators are the most illustrative for describing the balance in all systems of business process management criteria and allow implementing the modelling of the system of balanced business process management criteria, which is focused on a large data volume.

The result of formalization of the basic criteria for managing the flow of business process is provided in Annex B. The data in the table are specified on the example of the flow of operations of the Retail Department of ATB (business process “retail sales”). The basic characteristics of the model are determined based on the experience of ATB.

According to their values, the illustration of the system of criteria for managing the total workflow of the retail department of ATB not only determines the sequence of tasks, but identifies the estimated dates of the beginning of the workflow (1,2) (2,3) (3,4) (4,5) (5,6) (6,7) (7,10) according to the unified parameters of operations, which forms an image with a critical path flow lasting 35.6 hours. The most important indicators of the model for balancing the basic criteria are performance, cost, quality and time, fragmentation.

Masligan O. (2020) follows a similar approach to the illustrative model description of the BP on the unified parameters of operations is followed by within the dynamic programming of the functioning of tourism and recreation clusters in the regions. However, the author’s approach is focused on the production of balance in all systems of business process management criteria, so the illustrative model description is based on the system of balancing business process management criteria (work duration specified by two estimates - minimum $t_{min}(i,j)$ and maximum $t_{max}(i,j)$).

Accordingly, the system of balanced criteria of the network model of the business process of the Retail Department of ATB by the “reserves-value”method will be shown in Annex C. According to the results of network balancing, the values of the criteria will allow to perform a set of works in the period t_{cr} = 35.6 units of time while reducing the cost by 45 conventional currency unit. From. At the same time, the estimated probability of performing the whole set of works in 5 days is 25%.

For Krukevich (2015) and Postil (2019) which deal with the problems of workflow management of the business process network model, each non-critical path of the network diagram has its full-time reserve. A non-critical path is defined as the sum of all works that do not lie on the critical path. However, it is overlooked that each event of this path has its own reserve of time. Within the said study the systems of the criteria for managing the workflow of business process network model of the Retail Department of ATB by the “reserves-cost” method formed with the assumption that each non-critical path of the network diagram has its full-time reserve, and each event has its own time reserve.

According to the results of network modeling, it is clearly illustrated that the maximum term of the whole complex of works at a given level of probability of 80% is only 41.12 days. To significantly simplify the coding process and focus efforts directly on the implementation of the balancing system, it is advisable to supplement the system of criteria for business process management (Table 2): - balances by number of performers; - balances on the possibility of reducing the flow of work. Thus, it is illustrated that the data of such balancing is the possibility of minimizing the multidirectional impact on the workflows 3,4; 3.7; 4.5; 5.5; 5.9; 6.8.

According to the results of network modelling, it is clearly illustrated that the maximum term of the whole complex of works at a given level of probability of 80% is only 41.12 days.

To significantly simplify the coding process and focus efforts directly on the implementation of the balancing system, it is advisable to supplement the system of criteria for business process management (Table 2):

- balances by number of performers;
- balances by the possibility of reducing the workflow.

Thus, it is illustrated that the data of such balancing allow minimizing the multidirectional impact on workflows 3,4; 3.7; 4.5; 5.5; 5.9; 6.8.

Therefore, the critical path for additional balancing will be: (1,2) (2,3) (3,7) (7,10), and its duration is 36.6 hours, although there is no diversity of influence on workflows.

Representing the results of network modelling using a Gantt chart is typical for a large number of scientists. For example, Bizagi Modeler software (2020) illustrates the system of criteria for managing the workflow of the business process in the form of a band chart, which is one of the types of Gantt chart, while Iqbal, Zahid, Habib John (2019) supplement the band chart with a calendar schedule of workflows consisting of bands oriented along the time axis. In this case, each band along the time axis on the diagram represents a separate workflow or type of activity, its ends — the moments of start and completion of work, its length — the duration of work. In the works of Francescomarino, Ghidini, Maggi and Milani (2018) Gantt chart is a basic method of project planning and also consists of bands oriented along the time axis, but the vertical axis of the diagram is a list of tasks. The advantage of this approach is that this chart may, if necessary, outline the total tasks, percentages of completion, indicators of the sequence and dependence of work, markers of key moments, markers of the current time "Today" and others. According to available scientific papers, the key concept of the Gantt chart is a marker of a significant moment in the course of work or workflow, the common boundary of two or more tasks.

CONCLUSION

The topicality of the study is due to the fact that the proposed approach to modelling a system of balanced criteria for business process management considers the content of the balance of basic criteria of the business process.

The result-based conclusions are associated with judgments about the final features of modeling a system of balanced criteria for business process management. Its effectiveness is the search for balance. This balance is not just to form a network structure of its inherent works and achieve their goals, but to reproduce the model of essential features, which (even in a phenomenal acceleration of data accumulation and complication) contribute to the constant search for balance, interpretation of results and their presentation with existing real systems. The Gantt chart allows you to clearly illustrate the nature of the balance and the balancing map of the basic criteria (performance, cost, quality, time, fragmentation) for the workflow of the business process.

The practical value of modelling a system of balanced criteria is to obtain results that are easily perceived in the management of business processes and are effective in a continuous growth and distribution of information across multiple nodes of workflows. The obtained results can be applied in rationing and regulation of workflows by business processes. This is because the result of the illustration is in fact a description of the BP in real life, in a way that can be read many times to understand how the process works.

The proposed approach to modeling the system of balanced criteria of business process management is promising for making descriptions of BP in terms of automation of business process management using cloud computing math semester.

REFERENCE

BIZAGI MODELER. Business Process Modelling Software (BPM). The Digital Business Platform, Retrieved from: https: //www.bizagi.com, 2020.

BOOCH, G., RAMBEAU, J., & JACOBSON, A. UML. (User's Guide: DMK), 2000.

BOYCHUK, N. Optimization of business process management at the enterprises of Ukraine. Modern problems of economy and business, 17, 173-180, 2016.

CHORNA, N. An innovative approach to business process modeling. Bulletin of Khmelnytsky National University, 5, 155-158, 2011.

DEMIDENKO, V. Business process management as a component of the process approach to enterprise management. Effective Economics, 11, 15-19, 2015.

FRANCESCOMARINO, C., GHIDINI, C., MAGGI, F. M., & MILANI F. Predictive process monitoring methods: which one suits me best?, 16th International Conference, BPM 2018, Sydney, NSW, Australia, 462–479, 2018.

GADETSKA, Z. Modeling of business processes of enterprise activity. Effective Economics, 5, 49-54, 2016.

GLUSHCHEVSKY, V. Modeling of flow processes of distribution of resources and products on the network of business processes of the enterprise. Bulletin of KNUTD, 4 (89), 27-36, 2015.

HARRINGTON, D. Business Process Optimization, (St. Petersburg: Alphabet), 2002.

IQBAL, M., ZAHID, M., HABIB, D., & JOHN L. Efficient prediction of network traffic for real time applications. Journal of Computer Networks and Communications, 11, 2019.

KLEPIKOVA, O. The current state and place of information technology in enterprise management. Scientific Bulletin of the International Humanities University: Economics and Management, 5, 74-77, 2013.

KOMAR, V. Criteria modeling of quality of functioning of automatic control systems. Bulletin of the National University "Lviv Polytechnic", 596, 63-68, 2007.

KORZACHENKO, O. Modeling of business processes of enterprises: methodologies, approaches and methods. Scientific Bulletin of Kherson State University, 11, 171 - 175, 2015.

KRIVORUCHKO, O. Integrated approach to improving business processes. Economics of the transport complex, 32, 17-29, 2018.

KRUKEVICH, N. Gantt chart as a time management tool. Abstracts of the III International Scientific and Practical Conference, 203, 2015.

MAITA, A., MARTINS, L., & PAZ, C., PERES S. Process mining through artificial neural networks and support vector machines: A systematic literature review. Business Process Management Journal, 21, 1391–1415, 2015.

MASLIGAN, O. Network structure of functioning and analysis of tourism and recreation clusters. Effective Economics, 4,75-84, 2020.

MASLYGAN, O. The method of dynamic programming as a basis for the functioning of tourism and recreation clusters in the regions of Ukraine. Economic Horizons, 4 (7), 18-27, 2018.

POSTIL, S. Unified language for modelling information systems: University of the State Fiscal Service of Ukraine, 2019.

RYBALKO, L. Designing of organizational structure as an element of formation of quality management system in the field of trade of consumer cooperation. Economic strategy and prospects of trade and services development. 2 (4), 479–485, 2 006.

SAKHAROV, P. Rational Rose, BP win and others aspects of business process analysis. Director of Information Service, 11,2000.

SCHEER, A. Business processes Basic concepts, theory, methods, (Moscow: Vest), 2005.

TARANYUK, L. Development of processes of business modeling of industrial and sales enterprises in the conditions of the Third industrial revolution. Mechanism of economic regulation, 4, 9-22, 2016.

ANNEX A

Algorithms for formalizing the basic criteria for managing the workflow of BP “retail sales” of ATB

Criteria	**Criteria for workflow management**	**Algorithm**	**Main designations**	**Use of the received data**
Duration of work (tij) - a random variable	can take any value in the range oftmin (i, j) totmax (i, j)	values are selected by the program at random	Minimum estimatetmin (i, j), maximum estimatetmax (i, j)	modeling the main characteristics of the network model of the business process by the tabular method, the critical path and its duration
Expected durationtexp	Expected valuetexp (i, j) is assessed by the formula	$t_{exp}(i,j)=(3\ t_{min}(i,j)+2\ t_{max}(i,j))/5$		
Variance $S^2(i,j)$	the degree of scatter of possible values around the expected level	$S^2(i,j)=0{,}04(t_{max}(i,j)-t_{min}(i,j))^2$		
mm(i,j)	starti = 1 (of the initial event)	$t^e(1) = 0$		
early date of events completion$t^e(i)$	Calculation of the term of events completion	i = n: $t^e(n+1) = t^e(i) + t_{exp}(i,j\ n+1)$.Fori (initial event), obviously$t^e(1) = 0$	i - event; $t_{exp}(i,j\ n+1) – t_{exp}$of the initial and next i $t_{exp}(i,jn-1) – t_{exp}$of the final and previous (lines ending with the number of the penultimate event)	Modelling the event reserve R(i), using the algorithm$R^L_{i-j} =t^E(i)-t_{i-j} -t^L(i)$
Late date of events completion$t^l(i)$	When determining the late term of events completion, we move across the network in the opposite direction. Values are entered in the tables, if$t^L(i)$for the event min(t^L() - t;t^L() - t) = min(- ; -) is greater thantcr.	i = n: $t^e(n-1) = t^e(i) + t_{exp}(i,j\ n-1)$.For i = 10 (final event) the late date of the event must be equal to its early date (otherwise the length of the critical path will change)		
Length of the critical path T_{cr}	Equals early date of completion t^e.		t^e–final event	
Private reserve Type I, R_{ij}^1	part of the total time reserve by which the duration of work can be increased without changing the late date of its initial event	$R(i,j)= R^L(i,j) - R(i)$	Early datesstart$t_{ij}^{E.I.}$, completion$t_{ij}^{E.Exp}$ Late dates, start$t_{ij}^{L.I,}$ completion$t_{ij}^{L.Exp.,}$ R(i) reserve of events; t(i,j) – work duration; $R^n(i,j)$ –full reserve of work time; R(i) – event time reserve; Rj–time reserve for completion ofj[th] event;	Options for achieving balance, the behaviour of the model over time
Private reserve Type I, R_{ij}^1Type II orR_{ij}^C	the part of the total time reserve for which the duration of work can be increased without changing the early date of its final event. Indicates the location of reserves required for optimization	$R(i,j)= R^L(i,j) - R(j)$		
Independent time reserveR_{ij}^I	part of the full reserve obtained for the case when all previous works end at a late date, and all subsequent works begin at an early datet_{ij}.	$R^I_{i-j} = t^E(i)-t_{i-j}-t^L$		
Full time reserveR_{ij}^F	shows by how much the duration of all works belonging to this path can be increased, provided that the term of	$R^I_{i-j} = t^L_j-t_{i-j}-t^E(i)$		

	performance of all complex of works will not change. It is formed when the previous works are finished in the earliest term.			

Source: prepared on the basis of [4; 17; 18; 9, p. 9-22; 21, p. 190-300; 15]

Annex B

Systems of basic criteria for managing the workflow of the business process of the Retail Department of ATB
(balancing the duration of work according to the data of the Retail Department of ATB and Annex A)

Systems of workflow management criteria						**Characteristics of the model**													
						Calculation of the event reserve				**Optionofachieving balance, according to the model's behaviourover time**									
							Event completion term:					Early terms:		Late terms		Time reserve		Private reserve	
Work (i,j)	$t_{min}(i,j)$	$t_{max}(i,j)$	mm(i,j)	Expected duration$t_{exp}(i,j)$	Variance $S^2(i,j)$	Number of the event	early$t^e(i)$[1]	late$t^L(i)$[2]	Time reserve, R(i)[3]	робота (i,j)	Number of previous works	start $t_{ij}^{E.I.7}$	completion $t_{ij}^{E.Exp.7}$	starto $t_{ij}^{L.I.7}$	completion$t_{ij}^{L.Exp.7}$	full R_{ij}^{L5}	independent R_{ij}^{I6}	Type I, R_{ij}^{1}	Type II, R_{ij}^{C4}
1,2	10	12	0	10.8	0.16	1		0	0	1,2	0	0	10.8	-10.8	0	-10.8	0	-10.8	0
7,3	7	10	0	8.2	0.36	2	10.8	0	-10.8	1,4	0	0	7.2	-7.2	0	-7.2	15.4	-7.2	15.4
1,4	6	9	0	7.2	0.36	3	19	0	-19	2,3	1	10.8	19	-8.2	0	-19	10.8	-8.2	0
2,3	3	16	0	8.2	6.76	4	22.6	0	-22.6	3,4	1	19	22.6	-3.6	0	-22.6	19	-3.6	0
3,4	2	6	0	3.6	0.64	5	22.6	0	-22.6	4,5	2	22.6	22.6	0	0	-22.6	22.6	0	0
7,5	6	20	0	11.6	7.84	6	26.4	0	-26.4	5,6	1	22.6	26.4	-3.8	0	-26.4	22.6	-3.8	0
5,6	3	5	0	3.8	0.16	7	26.4	0	-26.4	5,9	1	22.6	32.8	25.4	35.6	2.8	22.6	25.4	0
6,8	2	10	0	5.2	2.56	8	31.6	35.6	4	6,7	1	26.4	26.4	0	0	-26.4	26.4	0	0
5,9	7	15	0	10.2	2.56	9	32.8	35.6	2.8	6,8	1	26.4	31.6	30.4	35.6	4	26.4	30.4	0
7,10	8	11	0	9.2	0.36	10	35.6	35.6	0	7,3	1	26.4	34.6	-8.2	0	-34.6	10.8	-8.2	-15.6
BP nodes	-	-	-	-	-	-	-	-	-	7,5	1	26.4	38	-11.6	0	-38	11	-11.6	-15.4
	-	-	-	-	-	-	-	-	-	7,10	1	26.4	35.6	26.4	35.6	0	26.4	26.4	0
	-	-	-	-	-	-	-	-	-	8,9	1	31.6	31.6	35.6	35.6	4	-2.8	0	1.2
	-	-	-	-	-	-	-	-	-	9,10	2	32.8	32.8	35.6	35.6	2.8	0	0	2.8
Algorithms for characterizing the critical path model (1,2)(2,3)(3,4)(4,5)(5,6)(6,7)(7,10) The length of the critical path is equal to the early completion of the final event 10: $t_{cr} = t^e(10) = 35.6$ Critical path length: 35.6																	R(i,j) = $R^L(i,j)$- R(i) - R(j)	R(i,j)= $R^L(i,j)$ - R(i)	R(i,j) = $R^L(i,j)$ - R(j)

1 calculation of "early" indicatort^E(i). Fori = 1 (initial event), obviouslyt^E (1) = 0. i = 2: t^E (2) = t^E (1) + t (1,2) = 0 + 10.8 = 10.8, i = 3: t^E (3) = t^E (2) + t (2,3) = 10.8 + 8.2 = 19., i = 4: max (t^E (1) + t (1,4); t^E (3) + t (3,4)) = max (0 + 7.2; 19 + 3.6) = 22.6., i = 5: t^E (5) = t^E (4) + t (4,5) = 22.6 + 0 = 22.6, i = 6: t^E (6) = t^E (5) + t (5,6) = 22.6 + 3.8 = 26.4, i = 7: t^E (7) = t^E (6) + t (6,7) = 26.4 + 0 = 26.4, i = 8: t^E (8) = t^E (6) + t (6,8) = 26.4 + 5.2 = 31.6, i = 9: max (t^E (5) + t (5,9); t^E (8) + t (8,9)) = max (22.6 + 10.2; 31.6 + 0) = 32.8, i = 10: max (t^E (7) + t (7,10); t^E (9) + t (9,10)) = max (26.4 + 9.2; 32.8 + 0) = 35.6.
2When determining the late dates of events t^L (i), we move along the network in the opposite direction, i.e. from right to left and use the formulae(3), (4).The length of the critical path is equal to the early completion of the final event10 t^L(10)= t^E(10)=35.6.Alllines are reviewed starting from 9.i=9: t^L(9) = t^L(10) - t(9,10) = 35.6 - 0 = 35.6, Alllines are reviewed starting from 5. (5,6): 0 - 3.8 = -3.8; (5,9): 0 - 10.2 = -10.2;i=5: min(t^L() - t;t^L() - t) = min(- ; -) = 0, Alllines are reviewed starting from 3. (3,4): 0 - 3.6 = -3.6; Alllines are reviewed starting from 8.i=8: t^L(8) = t^L(9) - t(8,9) = 35.6 - 0 = 35.6, Alllines are reviewed starting from 7. (7,3): 0 - 8.2 = -8.2;(7,5): 0 - 11.6 = -11.6;i=7: min(t^L(10) - t(7,10);t^L() - t;t^L() - t) = min(35.6 - 9.2; - ; -) = 0, Alllines are reviewed starting from 6. (6,7): 0 - 0 = 0;i=6: min(t^L(8) - t(6,8);t^L() - t) = min(35.6 - 5.2; -) = 0.(5,6): 0 - 3.8 = -3.8, Alllines are reviewed starting from 4. (4,5): 0 - 0 = 0; (3,4): 0 - 3.6 = -3.6;(4,5): 0 - 0 = 0; Alllines are reviewed starting from 2 (2,3): 0 - 8.2 = -8.2;Alllines are reviewed starting from 1. (1,2): 0 - 10.8 = -10.8;(1,4): 0 - 7.2 = -7.2;i=1: min(t^L() - t;t^L() - t) = min(- ; -) = 0.
3full reserve calculationR^Li-j: $R^L_{(1,2)}$ = 0-10.8-0 = -10.8$R^L_{(1,4)}$ = 0-7.2-0 = -7.2, $R^L_{(2,3)}$ = 0-8.2-10.8 = -19, $R^L_{(3,4)}$ = 0-3.6-19 = -22.6, $R^L_{(4,5)}$ = 0-0-22.6 = -22.6, $R^L_{(5,6)}$ = 0-3.8-22.6 = -26.4, $R^L_{(5,9)}$ = 35.6-10.2-22.6 = 2.8, $R^L_{(6,7)}$ = 0-0-26.4 = -26.4, $R^L_{(6,8)}$ = 35.6-5.2-26.4 = 4, $R^L_{(7,3)}$ = 0-8.2-26.4 = -34.6\, $R_{(7,5)}$ = 0-11.6-26.4 = -38, $R^L_{(7,10)}$ = 35.6-9.2-26.4 = 0, $R^L_{(8,9)}$ = 35.6-0-31.6 = 4, $R^L_{(9,10)}$ = 35.6-0-32.8 = 2.8
4 calculation ofR_{ii}^C RC (1,2) = 10.8-10.8-0 = 0, RC (1,4) = 22.6-7.2-0 = 15.4, RC (2,3) = 19-8.2-10.8 = 0, RC (3,4) = 22.6-3.6-19 = 0, RC (4,5) = 22.6-0-22.6 = 0, RC (5,6) = 26.4-3.8-22.6 = 0, RC (5,9) = 32.8-10.2-22.6 = 0, RC (6,7) = 26.4-0-26.4 = 0, RC (6,8) = 31.6-5.2-26.4 = 0, RC (7,3) = 19-8.2-26.4 = -15.6, RC (7,5) = 22.6-11.6-26.4 = -15.4, RC (7,10) = 35.6-9.2-26.4 = 0, RC (8,9) = 32.8-0-31.6 = 1.2, RC (9,10) = 35.6-0-32.8 = 2.8
5 calculation ofR_{ii}^L, $R^L_{(1,2)}$ = 0-10.8-0 = -10.8, $R^L_{(1,4)}$ = 0-7.2-0 = -7.2, $R^L_{(2,3)}$ = 0-8.2-10.8 = -19, $R^L_{(3,4)}$ = 0-3.6-19 = -22.6,$R^L_{(4,5)}$ = 0-0-22.6 = -22.6$R^L_{(5,6)}$ = 0-3.8-22.6 = -26.4, $R^L_{(5,9)}$ = 35.6-10.2-22.6 = 2.8, $R^L_{(6,7)}$ = 0-0-26.4 = -26.4, $R^L_{(6,8)}$ = 35.6-5.2-26.4 = 4, $R^L_{(7,3)}$ = 0-8.2-26.4 = -34.6, $R^L_{(7,5)}$ = 0-11.6-26.4 = -38, $R^L_{(7,10)}$ = 35.6-9.2-26.4 = 0, $R^L_{(8,9)}$ = 35.6-0-31.6 = 4, $R^L_{(9,10)}$ = 35.6-0-32.8 = 2.8
6 calculation of R_{ii}^I, $R^I_{(1,2)}$ = 10.8-10.8-0 = 0, $R^I_{(1,4)}$ = 22.6-7.2-0 = 15.4, $R^I_{(2,3)}$ = 19-8.2-0 = 10.8, $R^I_{(3,4)}$ = 22.6-3.6-0 = 19, $R^I_{(4,5)}$ = 22.6-0-0 = 22.6, $R^I_{(5,6)}$ = 26.4-3.8-0 = 22.6, $R^I_{(5,9)}$ = 32.8-10.2--3.5527136788005E-15 = 22.6, $R^I_{(6,7)}$ = 26.4-0-0 = 26.4, $R^I_{(6,8)}$ = 31.6-5.2-0 = 26.4, $R^I_{(7,3)}$ = 19-8.2-0 = 10.8, $R^I_{(7,5)}$ = 22.6-11.6--1.7763568394003E-15 = 11, $R^I_{(7,10)}$ = 35.6-9.2-0 = 26.4, $R^I_{(8,9)}$ = 32.8-0-35.6 = -2.8, $R^I_{(9,10)}$ = 35.6-0-35.6 = 0.
7 early and late dates of completion of the event are determined according tot^E(i) andt^L(i) by the relevant number fo event.
Source: generated inmath.semestraccording to the Retail Sales Department of ATB and Annex A.

Annex C

Systems of criteria for workflow management of the network model of the business process of the Retail Department of ATB by the "reserves-cost" method (balancing the duration of work according to Table 1 and Annex B)

Criteriasystems				Basic characteristics of the model							
				Generalized		Intensity coefficients					estimation of probability of performance of all complex of works in 5 days
Work (i,j)1	Free reserve R_{ij}^{C1}	Coefficient of costs for acceleration of works (UAH / day), h(i,j)2	Reduction of the unit cost of works, ΔC_{ij}	C1	Complexity coefficient	Patht_{cr}	Maximum path, t (Lmax)	Overlapping works	$t1_{кр}$	Intensity rate	
1,2	0	11.1		C1 = C - ΔC = C – 45 UAH	$K_c = n_{pab} / n_{cob=}$ = 10 / 10 = 1 Kc <1.5, the network diagram is simple.	(1,2)(2,3)(3,4)(4,5)(5,6)(6,7)(7,5)	38	1,1	0	1.067 (38-0)/ (35.6-0)	Critical path variance: $S^2(L_{cr})=S^2(1,2) + S^2(2,3) + S^2(3,4) + S^2(4,5) + S^2(5,6) + S^2(6,7) + S^2(7,10)$ $S^2(L_{cr})$=0.16 + 0.36 + 6.76 + 0.64 + 7.84 + 2.56 + = 18.32 $S(L_{кр})$ = 4.28 $p(t_{cr}<5)$=0,5+0,5F((5 - 35.6)/4.28)=0,5+0,5 F(-7.15)=0,5+0,5*(-0.49999) = 0.25 Probability is 25%
1,4	15.4	9	15.4*9 = 138.6			(1,4)(4,5)(5,6)(6,7)(7,5)	22.6	1,1	0	0.635 (22.6-0)/ (35.6-0)	
2,3	0	7				(1,2)(2,3)(3,4)(4,5)(5,6)(6,7)(7,5)	38	1,1	0	1.067	
3,4	0	2				(1,2)(2,3)(3,4)(4,5)(5,6)(6,7)(7,5)	38	1,1	0	1.067	
4,5	0	8				1,2)(2,3)(3,4)(4,5)(5,6)(6,7)(7,5)	38	1,1	0	1.067	
5,6	0	17				(1,2)(2,3)(3,4)(4,5)(5,6)(6,7)(7,5)	38	1,1	0	1.067	
5,9	0	12				(1,2)(2,3)(3,4)(4,5)(5,9)(9,10)	32.8	1,1	0	0.921	
6,7	0	9				(1,2)(2,3)(3,4)(4,5)(5,6)(6,7)(7,5)	38	1,1	0	1.067	
6,8	0	5				(1,2)(2,3)(3,4)(4,5)(5,6)(6,8)(8,9)(9,10)	31.6	1,1	0	0.888	
7,3	-15.6	6	-15.6*6 = -93.6			(1,2)(2,3)(3,4)(4,5)(5,6)(6,7)(7,3)	34.6	1,1	0	0.972	

7,5	-15.4		-15.4* = -0			(1,2)(2,3)(3,4)(4,5)(5, 6)(6,7)(7,5)	38	1,1	0	1.067	
7,10	0					(1,2)(2,3)(3,4)(4,5)(5, 6)(6,7)(7,10	35.6	7,1	9.2	1	
8,9	1.2		1.2* = 0			(1,2)(2,3)(3,4)(4,5)(5, 6)(6,8)(8,9)(9,10)	31.6	1,1	0	0.888	
9,10	2.8		2.8* = 0			(1,2)(2,3)(3,4)(4,5)(5, 9)(9,10)	32.8	1,1	0	0.921	
Algorithms for characterization of model reliability The maximum term of performance of all complex of works at the set level of probability is 41,12 days.											P(t_{cr} where $Z=(T-T_{cr})/S_{cr}$*

1data from the table in Annex B.

2 ATB data

*** Z -** normative deviation of a random variable, Scr - standard deviation, which is calculated as the square root of the variance of the duration of the critical path.

Source: generated in math.semestr according to the data of the Retail Sales Department of ATB provided in Table 1.