від того, наскільки простим, зручним та легко освоюваним є їхній користувацький інтерфейс;

● процес побудови користувацького інтерфейсу все ще залишається недостатньо формалізованим процесом, що робить дослідження у цьому напрямі дуже важливими для швидкого впровадження та ефективної експлуатації ІУС.

Література

1. *Коутс Р.* Интерфейс «человек-компьютер» / Р. Коутс, И. Влейминк ; [пер. с англ.] — М. : Мир, 1990. — 501 с.
2. *Венда В.Ф.* Системы гибридного интеллекта: Эволюция, психология, информатика / В. Ф. Венда. — М. : Машиностроение, 1990. — 448 с.
3. *Jeff Johnson* Designing with the Mind in Mind., Burlington, USA: Morgan komersants Publishe, 2010. — p. 188.
4. Разработка управляемого интерфейса / Ажеронюк В.А., Островерх А.В., Радченко М.Г., Хрусталева Е.Ю. — М. : ООО «1С-Паблишинг», 2010. — 723 с.
5. *Тео Мандел.* Разработка пользовательского интерфейса / Тео Мандел. — М. : ДМК Пресс, 2008. — 412 с.
6. *Жарков С.В.* Shareware: профессиональная разработка и продвижение программ / С. В. Жарков. — СПб. : БХВ-Петербург, 2002. — 322 с.

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OPTIMIZATION OF THE ELECTRONIC DOCFLOW DURATION BASED ON PETRI NETS AND CONTROLED BY GENETIC ALGORITHM

ANNOTATION. The article describes a method for determining the optimal duration of the document life cycle by a simulation model based on Petri nets. The parameters of this model are determined by the genetic algorithm. The author makes recommendations of using genetic algorithm for resource allocation problems.

KEY WORDS: Petri net, imitation modeling, risk, electronic document flow, genetic algorithm.

АНОТАЦІЯ. Описано метод визначення оптимальної тривалості життєвого циклу документу з використанням імітаційної моделі на основі мереж Петрі, параметри якої визначаються генетичним алгоритмом.

Сформульовано рекомендації з використання генетичного алгоритму для задач розподілу ресурсів.

КЛЮЧОВІ СЛОВА: мережа Петрі, імітаційне моделювання, ризик,електронний документообіг, генетичний алгоритм.

АННОТАЦИЯ. Описан метод определения оптимальной продолжительности жизненного цикла документа с использованием имитационной модели на основе сетей Петри, параметры которой определяются генетическим алгоритмом. Формулируются рекомендации по использованию генетического алгоритма для задач распределения ресурсов.

КЛЮЧЕВЫЕ СЛОВА: сеть Петри, имитационное моделирование, риск, электронный документооборот, генетический алгоритм.

Definition of the problem. In the present economic system, each company wants to operate in the existing conditions with the least risk in order to get high returns. First and foremost the question of optimization affected not only financial resources, but also docflow. Many top managers think that optimized docflow is the electronic document management systems using. However, companies can only partially reducing the various categories of costs — a number of risks are transferred from paper-based docflow to electronic, though these risks would have to be eliminated at the design stage of an electronic docflow.

One should note here that using an economic and mathematical model of effective design of electronic docflow can help to eliminate such risks. Firstly, this model allows us to find the optimal scheme of documents movement. Secondly, in such way we can minimize the total time of document life cycle. In addition, the model can solve the problem of inefficient distribution of documents between the performers. It is undeniable that such situation can help to minimize risks that arise at a particular stage of the document lifecycle.

The aim of the article is to validate the effectiveness of the method optimizing the duration of the life cycle of docflow based on the genetic algorithm control by Petri net.

The main material of the article. Formally, the problem of effective life cycle of the electronic document is as follows. Suppose an employee of the company to be treated n documents (or packages). Denote $L_{ij} = (q_{ij}, t_{ij})$ operation with the number i ($i = 1, m_j$), which is performed on the j-th document ($j = 1, n$); m_j — the number of operations to be performed on the j-th document; q_{ij} — number of the document lifecycle participants group (employees of one of the department) that is configured to perform an operation L_{ij}; t_{ij} — nominal duration of operations L_{ij}. Denote t_{ij}^0 as the beginning and t_{ij}^k as the end of the operation L_{ij}. In addition, there are normative values

of maximum permissible duration of the operation on the document by employee of one department. There must meet the following condition:

$$t_{ij}^{k} - t_{ij}^{0} \le t_{ij}.$$

Obviously, only one operation on the document is fulfilled at the moment. Given these constraints, there may be many ways of moving the document with different total duration. The set of numbers $P = \{t_{ij}^{0}\}$, that satisfy all the constraints, is an effective document lifecycle in the aspect of time. The solution of this problem is to find the unknown quantities $\{t_{ij}\}$. Formalized statement of the problem of optimization of the duration of the life cycle of the document you need to specify an objective function which each regulatory P assigns a certain number of $F(P)$, evaluates the effectiveness of the duration of the operation on the document. The problem of optimal scheduling time of an operation fulfillment on the document is to find a plan P^*, which has the extremum of the indicator F and certain conditions that described. To select the criterion of efficiency is carried out individually for each department according to the analysis of its features. of minimizing the delay of the untreated document, the total time spent, the load of workers are the most often used criterions for the efficiency [1].

Solving the problem of optimal planning of document lifecycle using a genetic algorithm-driven Petri nets is proposed in the article. The genetic algorithm is used to determine the initial position of the flow relations of network. Optimizing docflow expressed in minimizing the duration of the life cycle of the document. ***A simulation model of the process***. Let's consider the process of solving the problem on the example of incoming documents of the company, which operates in the energy sector.

Input documentation (correspondence) — documentation or other recorded information that was addressed and enrolled in the company. In addition to the document, such information may be in the form of file records by e-mail. It should be noted that this process always begins from chancery of the company, which is directly and process owner. The process of «Managing the input documents» begins with a step «Documents received in chancery», and the final step (process), «Management of the output documents.» Details of this process are depicted in Figure1.

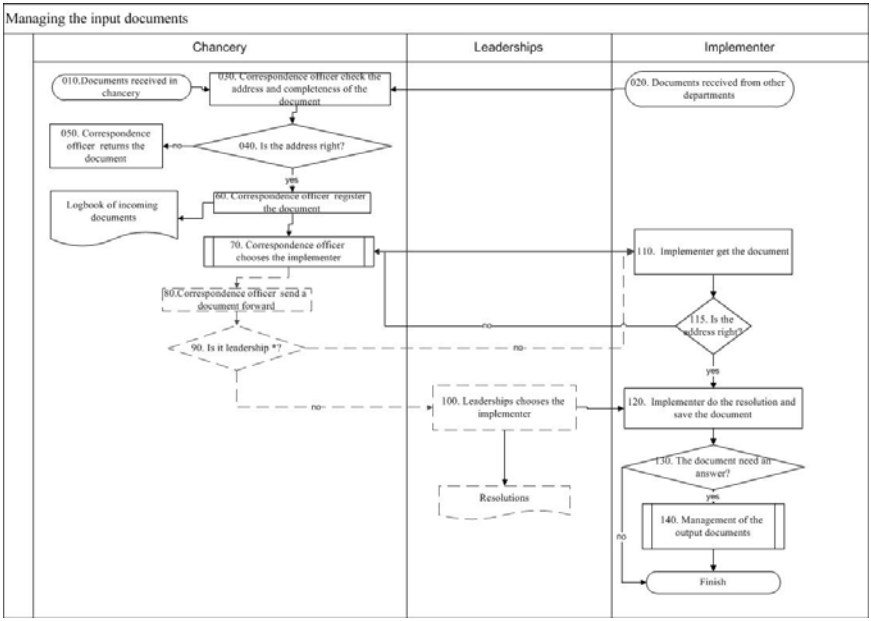

Fig. 1. The process of the input documents managing

Figure 1 depicts the process as it is, and how it should be after optimization. The reason for this was the fact that the design of the company's business docflow processes are treated fairly generalized and as a result top managers have to adopt resolutions for the most of the electronic documents (Figure 2). Thus document flow was unevenly distributed and until the document got to direct artist — passed a lot of time.

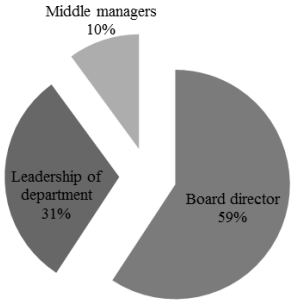

Fig. 2. Distribution of incoming documents
by chancellery between performers

Petri nets allow describing and analyzing the duration of the operations and interactions within the processes of different levels in order to identify bottlenecks industrial and economic systems, as well as determine the size and potential for reducing the cost of human, financial and other resources for the implementation of these processes. So the next figure shows the model of business process using Petri nets.

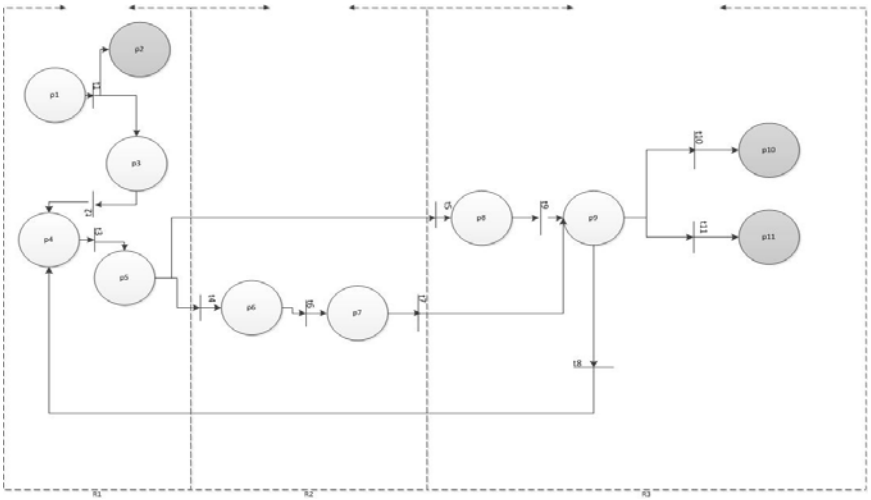

Fig. 3. Petri net of the process of «Managing the input documents»

There are transitions and positions shown in table 1 and 2 According to the functionality.

Table 1

MANAGING TRANSITIONS IN PETRI NETS

Transition	Control action
t_1	Correspondence officer checks the validity of the document addressing
t_2	Registration of the incoming document
t_3	Correspondence officer determines further destination (competent person)
t_4	If the condition «*k*», then the document is addressed to the leadership of the highest level
t_5	Unless the condition «*k*», then the document is addressed to the appropriate responsible department

Transition	Control action
t_6	Endorsement of the incoming document
t_7	Lines of responsibility in a department according to resolution
t_8	If the recipient is properly defined, the document is accepted
t_9	If the recipient is wrong, it returns the input document's Office
t_{10}	If the document requires a response, then the transition process «Management of the original documentation»
t_{11}	If the document does not require a response, you must save it in a data warehouse

As seen from figure 3 the process requires three resource groups to be performed:

- correspondence officer (group of correspondence officers)
- leaderships
- a department responsible for handling incoming document

Table 2

FUNCTIONALITY POSITIONS IN THE PETRI NET

Place	Assignment
p_1	an incoming document to chancery
p_2	input document is returned to the sender
p_3	input document is addressed correctly
p_4	registered the incoming document
p_5	identified all the details of the incoming document Chancellery
p_6	document received by senior level
p_7	identified responsible for processing the incoming document
p_8	document had responsibility in accordance structural division
p_9	worked inbound document
p_{10}	control of the output document
p_{11}	save the document in a data warehouse of department

Optimization algorithm. In general, the problem of optimizing the duration of docdlow is to define the optimal performer for each stage of the document lifecycle. Solution of this problem should be reduced to finding min (max) key performance indicators. Optimality criterion is chosen to minimize the total time of the document lifecycle.

Changing the flow distribution in the document is essential possibility to optimize [2]. Thus, there is the reduced number of

duplicated stages in the life cycle of the document. It should also be noted that you must consider the docflow options when determining the allocation. For example, within a particular business process of the document can only be operated with a rigid routing. Accordingly, the optimization will be carried out only by minimizing other risks at every stage of the document lifecycle.

The solution of this problem by means of Petri nets is expressed as the initial marking positions, markers, and control routes in the model. Marking control positions (p_k) determines which of the two positions on the document executed operation. Formally, the problem under consideration is as follows:

$$T = f(\mu_0(p_k)) \to \min_{\mu_0 \in M_0} \mathrm{T},$$

where $M_0 = \{\mu_0: \mu_{0i} \in \{0; 1\}, i = 1, n\}$.

Simulation methods specify the simulation experiment models, which are structurally similar to object modeling. Structural similarity of the model and the simulation object greatly simplifies the application of the current changes in the model. Simulation methods are based on the scheme of successive analysis of variants based on the current rules. [3] This circuit is connected with the stepper constructing variants using modeling process which simulates a document through the document lifecycle members (Fig. 4).

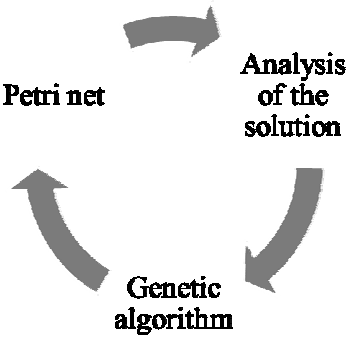

Fig. 4. Block diagram of the problem solving process

The main reasons for the use of genetic algorithm for solving this kind of problems:

1) only because of the genetic algorithm can determine the functional dependence of the optimality criterion on the initial positions of control markings;

2) take into account the particular nature of the marking control positions;

3) to solve large-scale problems.

Further this problem can be solved in Microsoft Excel in a sequence of steps:

1. Randomly generated initial vectors marking positions μ_0 (p_κ), or chromosome (ch_1, ch_2, ..., ch_i) and calculated estimates of the values of fitness function f (μ_0 (p_κ)) (table 3). The minimum possible number of individuals in a population is determined empirically. With less population process is more likely to converge to an erroneous optimum.

Table 3

AN INITIAL POPULATION OF CHROMOSOMES

# gene	*ch*1		*ch*2		*ch*3		*ch*4		*ch*5		*ch*6		*ch*7		*ch*8	
1	0	1	0	1	1	0	0	1	0	1	0	1	1	0	0	1
2	0	1	1	1	0	1	1	0	1	1	0	1	0	1	1	0
3	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
4	1	1	0	1	1	1	0	1	0	1	0	1	0	1	1	0
5	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
6	1	1	0	1	0	1	0	1	0	1	1	1	1	0	1	1
7	0	1	0	1	0	1	1	1	0	1	0	1	0	1	1	0
8	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
9	1	0	0	1	0	1	1	0	0	1	1	0	0	1	1	0
10	1	0	1	1	0	1	1	1	0	1	0	1	1	0	0	1
f(μ0($p\kappa$))	7	5	5	7	5	6	7	5	4	7	5	6	6	4	8	7

2. Selects chromosomes for mating. The selection mechanism — using traditional random selection. Table 4 show a pair of chromosomes for mating. It is assumed that exchange of genes carried out starting from the fifth gene (mid-chromosome).

Table 4

COUPLES PARENTAL CHROMOSOMES FOR THE NEXT POPULATION

*ch*3	*ch*4	*ch*1	*ch*8	*ch*1	*ch*3	*ch*6	*ch*7
The pair # 1		The pair # 2		The pair # 3		The pair # 4	

3. Generates a second population of chromosomes and determined the fitness function. Confirmation of the correctness of the algorithm, as a rule, is to reduce the average value of the fitness function (tabl. 5).

Table 5

THE SECOND GENERATION OF CHROMOSOMES

# gene	*ch*1		*ch*2		*ch*3		*ch*4		*ch*5		*ch*6		*ch*7		*ch*8	
1	1	0	0	1	0	1	0	1	0	1	1	0	0	1	1	0
2	0	1	1	0	0	1	1	0	0	1	0	1	0	1	0	1
3	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
4	1	1	0	1	1	1	1	0	1	1	1	1	0	1	0	1
5	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
6	0	1	0	1	1	1	1	1	1	1	0	1	1	1	1	0
7	0	1	1	1	0	1	1	0	0	1	0	1	0	1	0	1
8	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
9	0	1	1	0	1	0	1	0	1	0	0	1	1	0	0	1
10	1	1	0	1	0	1	1	0	0	1	1	0	1	0	0	1
f (μ0 (pκ))	6	6	6	5	6	6	9	2	6	6	6	5	6	5	5	5

One must continue to iterate until a certain chromosome is not close to the optimum value.

After the second iteration the values of the function decreased, and the eighth chromosome acquired values (5, 5). There is a document in the system will take 5 steps until complete its cycle. The experiment can be continued in order to find the optimal result.

Conclusion. Formulated the problem of optimal distribution of the document in terms of Petri nets has a practical application in the document management system.

As a result we get the network model of the system, the structure of which is presented separately for the position, describing the amount of resources.

The proposed approach of the problem of optimizing the duration of the life cycle of electronic docflow can be recommended for systems with different levels of complexity.

Due to this method decrease in time for finding the optimal or near-optimal solution will be most pronounced for systems with a large flow of documents.

When selecting the size of the population is recommended to minimize the number of chromosomes as each individual is associated with a separate simulation experiment. In practice it is recommended to select the population size in the range of 8 to 32 individuals, depending on the requirements of speed and accuracy solutions.

List of references

1. *Vasil'ev F.* Methods of optimization. — M.: Factorial Press, 2002. — 824 p.

2. *Simakov P., Antamoshkin A., Degterev D.* About optimizing production scheduling of discrete productions using imitating modeling // Managements Systems and Information Technology. — 2009. — № 1 (35). — P. 48–53.

3. *Stolbov V., Fedoseyev S.* Model of intellectual production management system // Management problems. — 2006. — № 5. — P. 36–39.

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МАТЕМАТИЧНЕ МОДЕЛЮВАННЯ ЩІЛЬНОСТІ АКЦІЙ В СКІНЧЕНОМУ ПРОМІЖКУ ЦІН

АНОТАЦІЯ. Розглянуто динамічну модель щільності розподілу акцій з дискретними початково-крайовими умовами. Систему початково-крайових умов перетворено до інтегрального вигляду. Побудовано функцію щільності розподілу акцій, яка є розв'язком рівняння моделі та наближено задовольняє початково-крайові умови згідно середньоквадратичного критерію.

КЛЮЧОВІ СЛОВА: функція щільності розподілу акцій, дискретні початково-крайові умови, система інтегральних рівнянь.

АННОТАЦИЯ. Рассмотрена динамическая модель плотности распределения акций с дискретными начально-краевыми условиями. Систему начально-краевых условий представлено в интегральном виде. Построено функцию плотности распределения акций, которая является решением уравнения модели и приближенно удовлетворяет начально-краевые условия за среднеквадратическим критерием.

КЛЮЧЕВЫЕ СЛОВА: функция плотности распределения акций, дискретные начально-краевые условия, система интегральных уравнений.

ABSTRACT. In this article the dynamic model of the shares density distribution with discrete initial-boundary conditions is considered. The system of initial-boundary conditions was converted to integral form. The function of shares density distribution was constructed. This function is an equation model solution and approximately satisfies the initial-boundary conditions in accordance with the root-mean-square criterion.

KEY WORDS: function of the density distribution of shares, discrete initial-boundary conditions, system of integral equations.