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INTRODUCING OPERATIONAL RESEARCH MODELS TO MANAGE THE COMPLEX PROTECTION OF INFORMATION OBJECTS

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Abstract

Operations research as an independent scientific discipline arose during the Second World War, when teams of practitioners were created to solve complex problems of logistics and design of weapons systems, which included specialists from various disciplines: mathematicians, engineers, economists, psychologists, financiers. These teams analyzed and quantified problems to find the best solution. In this research, some mathematical models were used in the development process of systems used in the fields of information security in the field of business. Where several examples have been presented illustrating the process of adaptation of mathematical models used in operations research in the fields of information security. Where the most important areas of application of these mathematical models have been identified, which ensures effective means of protection for those areas and at the same time works to quickly predict the risks that may occur in the areas of business.

Keywords: Modeling, business entities, informatization, system, objects, protection

INTRODUCTION

In various areas of practical activity in the organization of production and supply, the operation of transport, the placement of personnel, consumer services, healthcare, communications, etc. more and more often there are problems that are similar in formulation, have a number of common features and are solved by similar methods, which are conveniently combined under the general name of "operations research problems".

A typical situation is as follows: some purposeful event (a system of actions) is organized, which can be organized in one-way or another, that is, choose some kind of "solution" from a number of possible options. Each option has some advantages and some disadvantages, and, due to the complexity of the situation, it is not immediately clear which one is better (more preferable) than the others and why. In order to clarify the situation and compare among themselves, according to a number of signs, various solutions, a series of mathematical calculations is organized. Their task is to help people responsible for choosing a solution to make a critical analysis of the situation and, ultimately, to decide on one or another option.

The approach to these problems from a general rather than a narrow departmental standpoint has a number of advantages: it broadens the horizons of the researcher, ensures the mutual

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penetration and mutual enrichment of scientific methods, approaches and techniques developed in different areas of practice.

Operations research is a discipline concerned with the development and practical application of methods for the most effective management of various organizational and production systems.

Management of any system is implemented as a process that obeys certain laws. Their knowledge helps to find the conditions necessary and sufficient for the implementation of this process. To do this, all parameters characterizing the process and external conditions must be quantified and measured. Therefore, the main task of operations research is the quantitative justification of the decisions made on the organization of management.

The change in the format of information relations in modern society has revealed the problems associated with ensuring information security.

Theoretical and applied studies of the problems of ensuring the protection of objects and subjects of information relations are, as a rule, differentiated and focused, as a rule, on the development of protection methods that have a narrow specialization. Such a narrow-profile, separatist approach solves the problems of cryptographic, technical, anti-virus, etc. protection without regard to the general concept and independently of each other, which certainly reduces the effectiveness of protection [1].

The purpose of this study began the development of algorithms and models of complex protection based on special methods that ensure effective planning, forecasting and risk management in the process of interaction between subjects of information relations. Interest in this issue is due to the spread of digitalization processes, the development of tools and technologies for collecting, processing, storing data, the natural desire of owners to reduce the risks of information leakage.

The dynamic nature of the information security management system implies the presence of strategic, current and operational planning of means and methods of protection [2]. A comprehensive plan for the system of protection of info communication objects and relations is the main component of the system for ensuring the information security of the region and the state, a significant factor in the economic and political stability of society [3].

The relevance of the study of models and algorithms for the formation of integrated protection systems is due to many factors, including an increase in the number of cybercrimes, a change in the number and quality of attacks on data systems and communication channels, the intensive development of information technology and the incomplete compliance of subjects of information relations with the requirements that IT security managers impose to existing systems for collecting, processing, storing and transmitting data.

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RESEARCH METHODS

The study and comparative analysis of theoretical and applied research on the use of mathematical modeling methods in the practice of creating information security systems for info communication objects revealed the dominant nature of highly specialized research issues of anti-virus and cryptographic protection [4-6], protection of networks [7] and open systems [8], problems of technical protection of informatization objects [9-10]. Based on the study of the problems of ensuring information security, an integrated approach to the formation of the protection of info communication objects is proposed, which is based on the methods of operations research. The author's approach consists in integrating the tasks of ensuring the information security of objects/subjects of information relations in order to create a comprehensive protection system that minimizes damage from penetration into the system and/or unauthorized access to information [11].

Content analysis of available materials on the issues under study, carried out in the process of research, observation and expert evaluation of the protection systems of regional objects confirm the need for a systematic approach to the organization of complex protection of information and communication objects.

Research results. Model of complex protection of info communication objects based on the problem of equipment replacement Comprehensive protection of the object of informatization is a set of organizational, technical, hardware-software, cryptographic and anti-virus protection tools. With limited funding, the IT manager is faced with the task of creating a comprehensive plan based on the effective use of available protections. The use of complex expensive equipment in the technological production processes of the information security system poses a number of problems for the person responsible for making decisions. As a rule, these problems are associated with the need to address issues of efficient operation of equipment, timely scheduled preventive and preventive maintenance, as well as timely replacement of obsolete and/or obsolete equipment.

Operations research considers various options for the equipment replacement problem. In the context of this study, the author considered models that affect the effectiveness of the integrated protection of info communication objects, which is largely determined by the cost of acquiring technical means of protection. This item of expenditure, as a rule, ranges from 46.3% to 74.2%. That is why, according to the author, methods of operations research [12] are an effective tool for managing costs, which provide justification for decisions made, allow you to form an optimal strategy for selecting, operating and replacing equipment in the integrated protection of an info communication facility.

The problem of replacing equipment in order to prevent failure. Models of this class allow you to draw up a plan, the implementation of which reduces the likelihood of equipment failure. The proposed model provides an opportunity to determine the strategy of behavior and make a decision to replace the equipment or to continue the operation of existing technical means without replacement [13].

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STATEMENT AND MATHEMATICAL MODEL OF THE PROBLEM

Let some equipment be in operation, for which the costs associated with equipment failure (production defects, downtime) Com, as well as the costs of one replacement C3 are known; the number of non-failed equipment n (t) by time t is known; it is required to determine the optimal interval between successive replacements of equipment, at which the average cost per unit of time is minimized.

The probability of correct operation of equipment over time t is defined as the ratio of the number of pieces of equipment n(t) that have not failed by time t to the total number of equipment inspected n(0).

$$P(T \geq t) = p(t) = \frac{n(t)}{n(0)}$$

Where – n (t), the number of non-failed equipment by time t; n(o) is the number of surveyed pieces of equipment.

Mean equipment uptime for time t:

$$K_t = \sum_{t=0}^{t=1} P(i)$$

The values of the probabilities P (t) of the correct operation of the equipment are known;

The probability of equipment failure at age t will be 1 – P (t-1), then the average cost per unit of time Y_t

$$Y_t = \frac{C_{ot}(1 - p(t-1)) + C_3 p(t-1)}{K_t}$$

An illustration of the theoretical provisions is given in the example: the complex system for protecting the object has 20 pieces of equipment that provide video surveillance along the perimeter of the protected area. If at least one piece of equipment fails, the losses amount to 120,000 JD. Preventive replacement of individual elements of the video surveillance system, made in order to extend the service life, taking into account all costs, costs 75,000JD. It is necessary to determine the timing of equipment replacement in order to minimize operating costs; the probability of equipment failure is known (table 1).

Working hours	t	0	1	2	3	4	5	0	6
Number of units of serviceable equipment	n(t)	21	18	15	11	7	5		3

Table 1: Data on the probability of failure of video surveillance systems

The probability of proper operation of equipment after six years of operation is calculated by the formula

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$$P(T \geq t) = p(t) = \frac{n(t)}{n(0)}$$

The result of calculating the average uptime in table. 2.

Index	Equipment operating time t							
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**
n(t)	20	18	15	11	7	5	3	0
P(t)	1	.95	.8	.75	.6	.45	.1	0
K(t)		1	1,95	2.75	3.5	4.1	4.55	4.65

Table 2: The results of the calculation of mean time between failures

Assuming that C_{ot} = 120 JD, C_3= 75 JD. We determine the interval between equipment replacements: the optimal equipment replacement period falls on the fifth or sixth year of operation; with further use, the losses from failure and the costs associated with the replacement of equipment elements increase (Table 3).

Index	Equipment operating time t							
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**
K_t	0	1	1.95	2.75	3.5	4.1	4.55	4.65
C_{ot} (1-p(1-t))		0	6	24	30	48	66	108
C_t P(t-1)		75	71.25	60	56.25	45	33.75	7.5
y_t		75	39.6	30.54	26.64	22.68	21.91	24.22

Table 3: Summary Table of Results Analysis

The problem of equipment replacement taking into account cost reduction. When solving the problem of replacing equipment in order to prevent failure, the main goal is to determine such replacement periods at which the total costs of maintaining the equipment in good condition are minimal.

Statement and mathematical model of the problem. Let some equipment be in operation, the purchase price of which is S, the operating costs are known C1,C2,...,Ct, we assume that the price at the time of decommissioning is known - St and included in the costs Ct. It is required to determine after what time t the equipment should be replaced so that the total reduced costs are minimal. Consider the problem of replacing equipment, taking into account the reduction of costs to the current time. Since capital investments associated with the replacement of equipment are carried out at different times, it is necessary to bring later costs to current costs.\ using the ratio

$$K_{pr} = K_i \frac{1}{(1 +`E_{Sb})}$$

Where Kt - costs in t - period; t is the reduction period; E_{Sb} is the standard for bringing multi-time costs.

The cost minimization condition implies the fulfillment of the relation:

$Y_{t-1} > Y_t < Y_{t+1}$

Substituting the corresponding cost values into this condition and, having carried out transformations, we obtain:

$Y_t > C_t / (1\text{-}r)$ and $Y_t < C_t + 1 / (1\text{-}r)$

Where:

$$r = \frac{1}{1 + E_{Sb}}$$

Therefore, if the costs associated with the operation of equipment in the next period are less than the weighted average costs, then the equipment should not be replaced. It is advisable to replace the equipment if the cost of maintaining the equipment in good condition is greater than the weighted average costs.

Integrated protection models based on inventory management problem. An equally important item of expenditure in the formation of a system for protecting an info communication object is the cost of software and hardware. The timeliness of registration, placement and execution of applications allows you to maintain the necessary level of protection. Minimizing the cost of filing an application, purchasing protective equipment, delivery and storage, scheduling deliveries - this is an approximate list of tasks that an IT manager can and should solve, whose functions include the formation of a software and hardware protection system. The multi-criteria nature of the inventory management problem allows the decision maker\ to form an actual criterion at each planning stage, but, as a rule, economic indicators are chosen as an efficiency criterion, the commercial component of the protection system: total costs for stock formation, which imply accounting for placement costs order and purchase of goods, the cost of delivery and storage, possible losses from shortages, which are difficult to take into account, which include losses from violation of the integrity of the protection system and the cost of data recovery in the event that an info communication object was damaged due to an untimely update of anti-virus software , or the lack of physical protection means has led to a violation of the integrity of the object, the restoration of which requires additional, unpredictable and unplanned funding.

The advantage of mathematical models of inventory management is their diversity, which determines the conditions for the applicability of models to the problem of protecting info communication objects under study.

Single product inventory management model. The deterministic single-product inventory management model allows you to determine the total minimum costs for the formation of a stock, the intensity of consumption of which can be considered constant and known. This type of task includes managing the inventory of consumables in the system of technical means for ensuring information security, managing human resources and the system for preparing technological processes for data processing.

Data processing processes.

Conventions adopted in this model:

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K - The cost of placing an order;

Y - Stock level;

B - Intensity of stock consumption;

h - The cost of storing stock per unit of time;

t_0 is the time during which the stock ends or the time between two orders.

S - Total costs per unit of time.

Formulation of the problem. Determine the optimal size of the stock of a certain type of product (Y_{opt}), for example, motion sensors, video cameras, etc. the costs of registration and storage of which (S) are minimal if the intensity of consumption of this type of product is known, (B), as well as the costs of placing an order (K) and storing stock per unit of time (h). The total costs S are the sum of the costs of placing an order and the costs of storage:

$$S = \frac{K}{t_0} + \frac{h * Y}{2} = \frac{K}{{}^{y}/_{B}} + \frac{h * Y}{2}$$

To find the minimum of the total minimum costs S, we find the first derivative and set it equal to zero:

$$\frac{dS}{dY} = \frac{KB}{Y^2} + \frac{h}{2} = 0$$

We calculate the optimal stock size Y_{opt} and the total minimum costs S_{min} using the Wilson formula [14]:

$$Y_{opt} = \sqrt{({}^{2KB}/_{h})}$$

$$S_{min} = \sqrt{2KBh}$$

The presented mathematical model allows you to determine the order point $t_s = t_0 - t$, that is, the time of placing the next order; minimize the cost of delivery and storage of protective equipment belonging to different groups; allows you to create a schedule of deliveries.

Inventory management model with restrictions on the size of the warehouse [15, 18].

This model, adapted to the tasks of ensuring the information security of an object, makes it possible to rationally distribute a fixed amount of funding, determine the amount of funds allocated for the acquisition of a particular group of protection equipment.

When constructing a mathematical model of the inventory management problem with restrictions on the amount of financing, the method of Lagrange multipliers is used.

Conventions adopted in this model:

A is the amount of funding;

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y_i - the size of the stock of the i-th type of protective equipment (i=1, N)

a_i - area occupied by a unit of production of the i-th type

B_i, K_i, h_i, respectively, the intensity of demand for protective equipment, the cost of registration and specific costs for storing a unit of protective equipment of the i-th type.

Formulation of the problem. Let the demand B_1, B_2, ..., B_i, for i (i=1,n) types of protective equipment, the cost of placing an order for each group of means K_1, K_2,.., Ki and specific storage costs h_1, h_2, ... be known. ,hi ; unit price of goods of the i-th type (a_i). It is required to determine the optimal size of the stock of each type of y_{iopt} protective equipment, the total total cost of which is limited. Calculation algorithm:

1. The total minimum costs for each group are determined:

$$S_{y_1}, S_{y_2}, \ldots\ldots, y = \sum_{j}^{m} \sqrt{\frac{K_i B_i}{y_i} + h_i y_i/2}$$

2- Restrictions on the amount of funding $\sum_{j=1}^{n} a_i * y_1, \leq A;\ \ y_i > 0.$

3- The optimal stock size is determined for the i-th type of protective equipment

$$Y_{opt_i} = \sqrt{2 * K_i + B_i/(h_i - 2 * V_{opt} * a_i)}$$

CONCLUSION

The methodological approach based on operations research is invariant with respect to the subject area, and allows solving technical, technological and legal problems that take place in the structure of complex protection. Opportunities provided by operations research methods in the formation of information security systems for subjects and objects of information relations fully meet modern novelties, including an increase in the intensity of information flows, an increase in requirements for the degree of protection of confidential information, an increase in the number of attacks on data storage systems and communication channels. Moreover, others. The research conducted by the author, the experience of practical application of mathematical modeling methods to the development of plans for complex information protection, confirm the need and expediency of the systematic application of operations research to planning the protection of informatization objects.

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