Cost optimization for information security systems

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Abstract. Protecting information that is potentially accessible through external communication channels from external threats is one of the primary objectives of information security. Creating an information security system requires material investments, the cost of which increases along with the increasing degree of information protection. Therefore, the task of determining the level of investment in information security that provides the minimum total cost of the information protection system and losses from realized threats that remain after the implementation of the information protection system arises. In this paper, we present a scheme that allows us to solve the problem of optimizing the costs of an information security system, the implementation of which ensures a minimum of average total costs for the implementation of the information security system and losses due to the remaining threats realized after the establishment of information security system.

1. Introduction
In the present context, the protection of confidential information, especially databases localized in systems with a potential threat of breaking into the protection system and gaining access to the protected information, requires significant costs. Therefore, it is natural to formulate and solve the problems of optimizing (minimizing) these costs, provided that the necessary level of protection of the protected information from external influences is ensured. Obviously, losses from threats are uncertain and, therefore, the value of losses from threats is a random variable. As both threats themselves and the time intervals they occur and the threat costs are uncertain, depending on the defined objectives, various statements of the optimization problem can be used to establish a system of protection against threats [1-5].

For example, the task of optimizing the costs of an information security system can be formulated as the task of minimizing the maximum possible loss value at a given acceptable level of risk.

Another possible statement of the problem of optimizing the costs of an information security system can be formulated with respect to average losses.

2. Scheme of cost optimization for information security systems
In this paper, we consider a scheme for solving the problem of optimizing the costs of an information protection system based on minimizing the total costs of implementing the protection system and the average losses due to threats that can be realized after the protection system is established.

The objective function of the task of optimizing the costs of an information security system is as follows

\[ \psi(PL) = PL + ML(PL) \]
where PL is the cost of the protection system, ML(PL) is the average value of losses L(PL) from threats within the information security system, the implementation costs of which amounted to PL.

Statistics of the values of random variables (random function) L(PL) can be obtained in the process of experimental stage-by-stage testing of protection systems for different values of the costs of the protection system PL, or on the basis of a theoretical model of threats and their further reproduction for the calculated base period using the statistical scheme Monte Carlo test.

The ML(PL) function can be obtained using smoothing methods and based on them schemes and algorithms. To obtain ML(PL), it is necessary to use robust smoothing methods (extracting the deterministic component of the initial random function L(PL)) since threats can be of an anomalous nature in terms of the amount of possible losses.

Below is the robust smoothing scheme used in the work and the algorithm based on it, implemented in a computer program for calculating the optimal cost of the protection system.

Let the realized loss values L(PL)i, i = 1, ..., n be determined for the costs of the protection system (PL)i, i = 1, ..., n, respectively.

Then the smoothed deterministic component ML_sm(PL) of the chaotic function L(PL) is represented as an expansion [6]:

\[ ML_{sm}(PL) = \sum_{j=1}^{m} u_j \cdot \Phi_j(PL), \]  

where \( \Phi_j(x) \) is the basis system of linearly independent functions.

The coefficients \( u_j \), \( j = 1, ..., m \) of representation (2) are determined using an iterative process:

\[ \bar{u}^{(k+1)} = (A^T \cdot A)^{-1} \cdot A^T \cdot \bar{f}^{(k)}, k = 0,1, \ldots \]  

where \( k \) is the iteration number, the elements \( a_{ij}, i = 1, ..., n, j = 1, ..., m \) of the matrix \( A \) are determined by the equalities:

\[ a_{ij} = \Phi_j((PL)_i), i = 1, ..., n, j = 1, ..., m, \]  

and the components of the vectors \( \bar{f}^{(k)} \) are defined by the equalities:

\[ \bar{f}^{(0)} = (L_1, ..., L_n)^T, \]

\[ \bar{f}^{(k)} = (f_1^{(k)}, ..., f_n^{(k)})^T, k = 1, \ldots, \]

\[ f_i^{(k)} = L_i, \text{ if } i \in I_0^{(k)}, \]

\[ f_i^{(k)} = \sum_{j=1}^{m} u_j^{(k)} \cdot \Phi_j((PL)_i) + 1.8 \cdot \sigma^{(k)}(i), \text{ if } i \in I_+^{(k)}, \]

\[ f_i^{(k)} = \sum_{j=1}^{m} u_j^{(k)} \cdot \Phi_j((PL)_i) - 1.8 \cdot \sigma^{(k)}(i), \text{ if } i \in I_-^{(k)}, \]

where

\[ I_0^{(k)} = \left\{ i : \left| L_i - \sum_{j=1}^{m} u_j^{(k)} \cdot \Phi_j((PL)_i) \right| \leq 1.8 \cdot \sigma^{(k)} \right\}, \]

\[ I_+^{(k)} = \left\{ i : L_i - \sum_{j=1}^{m} u_j^{(k)} \cdot \Phi_j((PL)_i) > 1.8 \cdot \sigma^{(k)} \right\}, \]

\[ I_-^{(k)} = \left\{ i : L_i - \sum_{j=1}^{m} u_j^{(k)} \cdot \Phi_j((PL)_i) < -1.8 \cdot \sigma^{(k)} \right\} \]

\[ \sigma^{(k)}^2 = \sum_{j=1}^{m} (L_i - \sum_{j=1}^{m} u_j^{(k)} \cdot \Phi_j((PL)_i))^2. \]

The iterative process (3) - (12) converges within a finite number of iterations [6].

Figure 1 demonstrates the test source data and the results of processing it in the process of solving the problem of optimizing the costs of an information security system. Initial test data on losses due to threats were obtained using a generator of normally distributed random numbers taking into account the monotonous decrease of the ML(PL) function with an increase in the cost of the protection system.

The graphs of the functions \( \psi(PL) \) and ML(PL) in Figure 1 are indicated by dashed lines. Figure 1 illustrates the optimal cost value \( PL_{opt} \) at which the minimum value of the objective function \( \psi(PL) \) is met.
3. Commentary

It should be noted that not for any system of protecting information from threats there is a minimum of the objective function $\psi(PL)$ with a positive value of $PL$ costs.

Indeed, in the case that the function $ML(PL)$ decreases monotonically, the derivative $\frac{dML(PL)}{dPL}$ satisfies the inequality $\frac{dML(PL)}{dPL} > -1$, the objective function $\psi(PL)$ monotonically increases and, therefore, the equipment of such an information protection system is not effective and cannot be used for information security of the system at hand of the type in question.

4. References

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