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THE EFFICIENCY ESTIMATE METHOD FOR FORMATION OF COMPLEX SECURITY INFORMATION PROGRAMS

This paper proposes a method for constructing a hierarchy of the complex program to ensure information security (SPEIS) taking into account the threats and risks. Methods for determining the quantitative indicators of relative effectiveness, taking into account threats and risks, were described.

The stages of decision support technology taking into account threats and risks are developed and presented. These stages are based on the method of goal-oriented dynamic estimation for the complex program to ensure information security. Stages of the goal-oriented dynamic estimation method include the following steps: the stage of goals constructing the hierarchy for the complex program to ensure information security (SPEIS); the stage of input it into of threats and risks models. On this basis the following evaluation tasks are being solved. The problem of the relative efficiency for directions of the implementation of SPEIS, taking into account threats and risks is being solved. The problem of programs (tasks) relative effectiveness that set by a multitude of threats and risks is solved. The task of using counteraction means to threats and risks is solved. These tasks are solved under the condition that the SPEIS is formed for a given time interval. It is shown that the basis for them is the problem of estimating the relative effectiveness that a given set for SPEIS problems. The above-proposed algorithm to solve this problem taking into account the threats and risks was considered.

This technology can be used for complicated complex goal-oriented programs for various purposes.

Keywords: security program, decision making, protection system, DSS, decision support system, evaluation, simulating, judgement.

Introduction

Problem solving of the state information security can be obtained with the use of decision support systems. Decision-making is a compulsory step in any purposeful activities. Thus in the conditions of limited resources of all kinds, and increase of activities is continuously increasing difficulty decisions that are made, and the requirements for their efficiency.

The complex program to ensure information security (CPEIS) is a set of activities united by unity of global goals and shared resources. The main objectives of the complex program to ensure information security development (CPEIS) is a selection of programs to be included in the complex program and the resources distribution between programs. This complex program to ensure information security (CPEIS) usually can be scheduled for long intervals of time, so we need to evaluate the effectiveness of programs in a given time interval.

It is necessary to take into account the possibility of threats and risks during developing the complex program to ensure information security (CPEIS). Analyze their impact and on this basis provide for measures to counter them or eliminate them.

We need to solve the following problems in the formation for the complex program to ensure information security (CPEIS) considering the threats and risks:

- we need to determine the quantitative characteristics influence of threats and risks to the effectiveness of the complex program to ensure information security (CPEIS);
- we need to identify quantitative rates of the performance program considering threats and risks;
- we need to divide resources between counter means of threats and risks, and programs with goal to increase information security.

This article is a continuation of the paper [1] and is devoted to the presentation of a method for describing of comparative danger for threats and risks. In addition, this article is devoted to complex program to ensure information security (CPEIS), taking into account the threats and risks. The method is a modification of a method for the goal-oriented dynamic estimation of programs and tasks on a time interval [2].

Main goal of the article

The goal consists in developing of the stages of decision support technology taking into account threats and risks. These stages are based on the method of goal-oriented dynamic estimation for the complex program to ensure information security. Stages of the goal-oriented dynamic estimation method include several steps.

Main part

The construction of sub-goals hierarchy is carried out in three stages. At the first and second stages, the hierarchy of goals is constructed without taking into account threats and risks. The models of these factors (threats and risks) are introduced into the hierarchy at the third stage. In this case, the first stage is carried out from up to down, and on the second – vice versa – from down to up.

The essence of the first stage (procedure) is as follows. Let's ask the expert: "Does achievement of any sub-goals influence to the achievement of the program main goal?". These $\lambda_1, \lambda_2, \dots, \lambda_n$ will be sub-goals. It is possible to raise the question concerning any of them: "Is it possible to express the result of the sub-goal complete achievement by the result of a value (effect) measurement?". If the answer is yes, then we have a sub-goal which is quantitative by its output, otherwise, we have a qualitative one. If the sub-goal is quantitative by output, then the expert should determine: "Is the value of the effect known to be accurate?". If the answer is yes, then we have a definite sub-goal that is quantitative by its output, otherwise it is undefined quantitative by its output.

Then the expert determines: "Is the sub-goal achievement positively affect to the above-goal achievement or not?". In addition to defining a set of sub-goals, the first procedure involves defining also the type of above-goal. Let's ask the question: "Is it possible to express the condition for achieving above-goal as the result of measuring a certain real quantity (resource)?". If the answer is positive, the goal is quantitative by input, otherwise the goal is qualitative by input. If the goal is quantitative by input, then the expert should determine: "Is the value of the resource certainly known?". If the answer is yes, then we have a defined quantitative goal by input, otherwise, we have the undefined quantitative goal by input.

Let's consider the sub-goal λ_1. At this stage, the expert should determine: "Is the sub-goal λ_1 to be the goal of a task or program implementing?". If the answer is yes, further decomposition of sub-goal λ_1 is no need. If the answer is not, then we ask the same question that relates to the main goal, but now instead of the main goal in the question will be the sub-goal λ_1. In addition, when we are determining the sub-goals for λ_1, we firstly try to find sub-goals among the list of goals that were previously called in the analysis of other above-goals. This list can also contain the main goal of the program. Due to this, feedbacks can be established between the sub-goals and the above-goals.

Now the expert should determine the type of goal λ_1, by asking the same questions as for the main goal. In addition, the expert asks the question: "Does any the degree gain achievement of sub-goals of the goal λ_1 influent to degree of it achievement?". If the answer is yes, then we have a quasi-linear goal λ_1, otherwise the goal λ_1 is a threshold ($\Pi_1 > 0$). In the second case, the expert determines the value of its threshold. What should be the achievement degree of the goal, so that it would affect the achievement degree of the main goal. We repeat this process for all sub-goals pointed in the list and build a hierarchy of sub-goals, the achievement of which is influenced by the implementation of the complex programs to ensure information security (CPEIS). It is easy to see that the implementation of the described algorithm will always ensure that all complex programs to ensure information security (CPEIS) are included in the hierarchy. However, the decomposition of not all sub-goals of the first level necessarily ends with any task. This is due to the fact that, in general, the problem may not reflect all aspects of (CPEIS) main goal achievement. Since the condition for the decomposition complete of some above-goal is the match of some of its sub-goals with the goal of the (CPEIS), in the general case at least one sub-goal of the first level will be discovered, the decomposition of which never ends, because such a task is absent in the hierarchy. In order for the algorithm to complete its work in a finite number of steps, we introduce one more condition for stopping its execution. The decomposition of all goals is completed, as soon as the goal of any task is matched with some sub-goal. Previously described the hierarchy-constructing algorithm of goals for selecting the most effective tasks, which should be included in the complex programs to ensure information security (CPEIS). Also, the proposed method can be applied to determine the most effective directions for the implementation of the complex programs to ensure information security (CPEIS), which it are advisable to support by asking appropriate tasks. In this case, the hierarchy is constructed similarly, with the only exception that the creator of the complex programs to ensure information security (CPEIS) itself determines the degree sufficiency of detail and itself stops further decomposition.

At the second stage, the upwards moving procedure is performed. The procedure consist in the fact that for each sub-goal all direct above-goals are defined, so goals, the achievement of which is directly influenced by the achievement of the analyzed sub-goal.

At the last stage, models of threats and risks are introduced into the hierarchy. In [1] the threat model is proposed. The threat model affects on several purposes and, possibly, programs. Experts consistently analyze the entire set of goals and programs (tasks) introduced into the hierarchy, which were introduced in the previous two (the first two) stages. This is done to determine the effect on these elements of the hierarchy. Then the experts determine the impact of the corresponding threat on them. Note that tasks that are models of threats can have sub-goals (sub-tasks) that serve as models for threats neutralizing. They are also defined as sub-goals of ordinary goals.

The introduction of risk models is as follows. First, the risk factors that must be taken into account are determined. Then, in accordance with [1], goals are constructed. These goals are indicators of the corresponding risks. Then their parameters are defined, similar to the way it was for the main hierarchy. At the last step, the links of the introduced risk indicators are established with the elements of the constructed hierarchy (goals and tasks).

Estimation of the relative effectiveness of program elements taking into account risks and threats provides for the solution of the following assessment tasks:

- the relative effectiveness of the program implementation direction, taking into account threats and risks;
- the relative effectiveness of a given set of threats and risks; the relative effectiveness of countermeasures to threats and risks.

The basis of the proposed method is determined by two main ideas. The degree of task influence (program goal achievement) on the degree of main goal achievement of the program is used as an indicator of efficiency. The hierarchy of program goals includes tasks that are threat models or risk indicators.

The assessing task of CPEIS, taking into account the threats and risks of the relative effectiveness of programs over a time interval, taking into account threats and risks, is to judge the influence degree on the achievement of the main goal the programs (tasks), which are judge, in the presence of these factors. Then we use the concepts of simple and complex programs (tasks) [2]. Simple is called the program, considered within the framework of the (CPEIS), as a single whole. At the same time, a complex program (task) consists of a series of interdependent simple programs.

The partial coefficients of sub-goals influence and programs (tasks) in the general case depend on time. Therefore, the achievement degrees of above-goals, including the main, also depend on time. Consequently, we can speak about the instantaneous values of the performance indicators for simple and complex programs (tasks).

Definition 1. The instantaneous value $\varphi_k(t)$ of the relative efficiency index (REI) of a complex program (task) CD_k at time t from the beginning of its implementation is equal to

$$\varphi_k \ t) = F[A_0 \ D)_t, A_0 \ D \backslash CD_k)_t],$$

D is the set of all simple programs (tasks) of CPEIS;

$A_0 \ D)_t$ – is the achievement degree of the main goal at time t, if all simple programs (tasks) are included in the CPEIS $SD_i \in D$;

$A_0 \ D\backslash CD_k)_t$ – is the achievement degree of the main goal at time t, if all simple programs (tasks) are included in the CPEIS $SD_i \in D$, except for simple programs (tasks) that are involved in a complex task (program) CD_k;

The form of the function *F* (for example, the difference, the ratio, etc.) does not depend on the hierarchy structure and goals type. The form is determined by the convenience of the information perception by the decision-maker (DM).

Thus, the *CD* can be characterized by a set of instantaneous values of its relative efficiency index, computed for a set of time instants on a certain given interval τ. In this case, the estimation of the set *CD* in the course of the decision making is add up to the calculation of a certain function *T*, which is defined by DM. This function is defined on the values set of the relative efficiency indicators for the problem (program) at the instant of time from the interval τ. As such, a function can be used:

$$T_k = \sup_{0 \le t \le \tau} (\varphi_k \ t))$$

or

$$T_k = \int_0^{\tau} \varphi_k \ t)^* dt$$

$\varphi_k \ t)^*$ – is the best approximation of the set for instantaneous values of $\varphi_k \ t)$ for the time moments of interval [0, τ] with respect to some criterion (for example, providing a minimum of the sum of mean-square deviations). The problem of estimating a simple program within the limits of a given complex program arises in addition to the task of estimating a complex program.

Therefore, a relatively simple task (program) SD_i we can talk about the value of the index φ_{ik} its relative effectiveness within the boundaries of a complex program (task) CD_i. In general

$$\varphi_{ih} \neq \varphi_{ik}; h \neq k.$$

Definition 2. The instantaneous value $\varphi_{ik}(t)$ of the relative efficiency index for a simple task and the SD_i program in the complex task CD_i at time t from the start of CD_k implementation is equal to

$$\varphi_{ik} \ t) = F(\varphi_k \ t), \varphi_{k\neg i}),$$

where $\varphi_k \ t)$ – is the value of the relative performance indicator for a complex task or program

CD_k at the time t;

$\varphi_{k\neg i}$ – is the value of the relative performance indicator for a complex task or program CD_k at the time t, which does not contain a simple program or task SD_i . In general

$$\varphi_{ih} \neq \varphi_{ik}; h \neq k.$$

Thus, the dynamic estimation of a simple task (program) $SD_i \in CD_h$ during the determination of the indicator of its relative efficiency at a given time interval is reduced to the calculation of the relative efficiency indices of two complex tasks CD_h and $CD_{h\neg i}$ at a certain set of time points from this interval. In turn, the task of calculating the indicator of relative efficiency CD_h is reduced to the calculation at these times of the quantities:

- $A_0 \ D)_t$ – the degree of main goal achievement at time t provided that all $SD_i \in D$;

- A_0 $D\backslash CD_k)_t$ – the degree of main goal achievement at time t provided that all $SD_i \in D$, with the exception of simple programs that are included in the CD_h. The specified conditions, under which the degree of achievement for the main goal is calculated, is determined by the set. In the programs (tasks) which are analyzed this set is conveniently set by the vector $A_B = \left\{A_{B_q}\right\}$, $q = \{1, |D|\}$, the degree of programs or tasks implementation whose components

$$A_{B_q} = \begin{cases} 1, if\ SD_q \in B; \\ 0, if\ SD_q \notin B. \end{cases}$$

Thus, the problem of the relative efficiency calculating for simple and complex tasks or programs is reduced to computing the degree of achievement of the main goal at a number of times, provided that the degree implementation of the programs $SD_q \in B \subseteq D$ is given by the vector A_B.

We first consider the method of estimating a complex problem or program at a given time *t*. The problem is formulated as follows.

Given:

- time t from the interval $[0, \tau]$;
- oriented graph of the hierarchy of goals *H(G,V)*, where $G = \{g_s\}, s = (0, n)$ is the vertex set, each vertex g_s is denoted by the A_s $t)$ function of the degree goal achievement [1];
- for each vertex g_s there is given a set $G_s = \{G_{sz}\}$ of compatible vertex-precursors sets;
- $V = \left\{v_q\right\}, q =$ $1, b)$ is the set of arcs, each arc has weight (a partial coefficient of influence according [1]);
- vector A_B, defined by the expression (1) in accordance with the values at the time t for the random processes specifying threats and risks.

We need to determine the values of the function $A_0(t)$ of the degree achievement for the main goal, provided that $\forall\ g_p\ \in B \subseteq D \subset G\left[A_q\ \ t) = A_{B_q}\ \ t)\right]$.

The determination of the components for the vector B at the time t which define the threat and / or risk model programs is carried out in accordance with the values of the random processes describing these factors, similar to how the probabilities of implementing other programs or tasks are taken into account [3].

We will determine the method for calculating the REI for the most general case, when the network hierarchy, nonlinear, nonmonotonic with positive and negative feedbacks, has both linear and threshold purposes. The search for a method of constructing an analytical expression that makes it possible to compute the degree achievement for the main goal seems hopeless because of the complexity of the analytic description of the graph of an arbitrary structure. This is further aggravated by the fact that in the practical application of this decision support method, it becomes necessary to evaluate the effectiveness of programs and tasks for various purposes and to quickly change the structure of the hierarchy when the system is escorted. Therefore, we use the method of solution, which is based on modeling the hierarchy of goals. The hierarchy is modeled according to such an algorithm.

Step 1. $x \coloneqq 1;\ \forall\ 0 \leq s \leq m[A_s\ \ t_i)^0 \coloneqq 0]$,

where $A_s\ \ t_i)^x$ – function value $A_s\ \ t_i)$ on *x* iteration.

Step 2. $\forall\ g_p\ \in B \subseteq D \subset C\left[A_q\ \ t_i)^x \coloneqq A_{B_q}\ \ t)\right]$.

Step 3. We need to find a subset $G_u = \{g_s\}$ of the graph vertices for which $A_s\ \ t_i)^x \neq A_s\ \ t_i)^{x-1}$.

Step 4. We need to find a set G_c of the graph-precursor vertices $g_s \in G_u$.

By using [1], we need calculate the values of the functions $A_s\ \ t_i)^x$ для $g_s \in G_c$.

Step 5. If $g_0 \in G_c$, then go to step 6, else step 7.

Step 6. If

$$|A_0\ t_i)^x - A_0\ t_i)^{x-1}| \leq \Delta, \quad (2)$$

where Δ – acceptable value calculation inaccuracy, then step 8, else $x \coloneqq x + 1$.

Step 7. $G_u = G_c$.

Step 8. The end of algorithm.

It is easy to see that for such a procedure of calculating the degree achievement for the main goal of the full implementation of the tasks and d_j programs should be calculated degree achievement of sub-goals $g_i \in G^*$.

$$G^* = \bigcup_j G_j\ ;\ G_j = \bigcup_q G_{jqi},$$

where G_{jq}– is sub-goal sets that enter into the q path in the graph of sub-goal hierarchies which leads from the vertex denoted by the task d_j to the vertex g_0, denoted by the main goal of the CPEIS.

Note that in the general case, in network type hierarchies, $q > 1$, so there can be many such paths. This means that the execution of the same program or task affects the achievement of several sub-goals. Achieving a sub-goal, as a rule, affects the achievement of several above-goals but not only one. This gives rise to many ways from one task or program to the main goal.

The pointed algorithm is executed N times, and the number of repetitions depends on the required accuracy of calculations, after that the mathematical expectation of the degree achievement value for the main goal at time t is determined.

The next time instant t_{i+1} is established from the following considerations. The degree of achievement for the main goal at this moment is uniquely determined by the degrees of achievement for all sub-goals that are on the paths from programs (tasks) to which in the vector A_B there correspond units and instantaneous values of their influence coefficients at this instant of time.

Since the degrees of achievement of all sub-goals computed at the time t_i do not change in the interval $t_i - t_{i+1}$, then the degree of achievement for the main goal can change at timet_{i+1} in comparison with the time t_i , only if to the beginning of t_{i+1} at least one sub-goal the influence coefficient, instead of zero will take a stationary value. Therefore, t_{i+1} will be determined from the expression $t_{i+1} = \inf_{e_j \in E_i^0}(e_j)$, where $T_i^0 =\ \ e_j \geq t_i)$ is the set of system time values, do not less than t_i, in which events occur in the hierarchy (program or task execution, completion of the spread for influence of sub-goal achievement).

In the presence of feedbacks in the sub-goal network, it is necessary to calculate the degree of achievement for the main goal in an infinite number of iterations, which we determine, based on the acceptable accuracy of the results, so from condition

$$\gamma(u+1) = |\mu_a\ u+1) - \mu_a\ u)| \leq \Delta \ll 1, \quad (3)$$

where $\mu_a\ u+1), \mu_a\ u)$ – are values of a simple program performance indicator d_a, calculated on $\ u+1)$ and $u - th -$ iterations, respectively;

Δ – is acceptable inaccuracy in calculation.

The stability condition of the iterative process, means the conditions under which (3) holds for a finite u, are determined [4, 5].

In the assessing mode of the relative effectiveness for the CPEIS directions in view of threats and risks, the components of vector B corresponding to programs and tasks that do not serve as threat models and risk indicators but are determined in a manner analogous to that described above. After this, the relative effectiveness indicators of each goals modeling the CPEIS execution directions are determined in the manner described above.

The relative effectiveness estimation of a given set for risks and threats is similar to the above mode of evaluating the set of programs (tasks). The evaluation is carried out on the basis of [1], because the threat model is a program (task), and the risk model is a risk indicator, which is also a sub-goal.

The relative effectiveness estimation of counteraction means to risks and threats, taking into account that there are means of counteraction to risks and threats – programs (tasks), is carried out in a manner analogous to the evaluation of programs (tasks) considered above.

Conclusions

In this article, the stages of decision support technology taking into account threats and risks are developed and presented. These stages are based on the method of goal dynamic estimation for the complex program to ensure information security. Stages of the goal-oriented dynamic estimation method include the following steps: the stage of goals constructing the hierarchy for the complex program to ensure information security (SPEIS); the stage of input into it of threats and risks models. On this basis the following evaluation tasks are being solved. The problem of the relative efficiency for directions of the implementation of SPEIS, taking into account threats and risks is being solved. The problem of programs (tasks) relative effectiveness that set by a multitude of threats and risks is solved. The task of using counteraction means to threats and risks is solved. These tasks are solved under the condition that the SPEIS is formed for a given time interval. It is shown that the basis for them is the problem of estimating the relative effectiveness that a given set for SPEIS problems. The above-proposed algorithm to solve this problem taking into account the threats and risks was considered.

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