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OPTIMIZATION OF RESOURCES DISTRIBUTION OF RADIO SUPPRESSION MEANS AND DESTRUCTIVE PROGRAM IMPACT ON ELECTRONICS NETWORKS

Methodological approaches to the development of scenarios for complex radio suppression and electromagnetic effects of typical electronics systems have been developed. However, in the development of possible scenarios for the integrated usage of radio suppression and destructive program action, the problem of resource optimizing the of these means and their distribution among radio suppression targets and objects of destructive computer action has not been developed in full. Therefore, it is necessary to formulate the problem and develop a methodology for optimizing the resource allocation of radio suppression means and destructive program action in the development of possible scenarios for disruption of information exchange by an adversary in a typical electronics network. The aim of the research is to improve the methodology for optimizing the resource allocation of radio suppression means and destructive program action for the development of scenarios for violation of information exchange by an adversary in an electronics network. To achieve the goal of the research, methods of nonlinear optimization of the distribution of a heterogeneous resource were applied. To determine the security factors of objects of radio-electronic influence and destructive computer influence, the method of frequencies of preferences of the person making a decision was applied using the Thurstone method. To solve the problem of optimal distribution of a heterogeneous resource of means of destructive influence to ensure the value of a multiplicative objective function of an arbitrary type not less than a given one, the method of successive increments was applied. At the same time, the methods of the queuing theory are used to determine the efficiency indicator of the violation of information exchange. It allows formalizing electronics systems as a set of queuing systems – digital communication subsystems and computer networks. The problem formulation was carried out. The introduced indicators made it possible to solve the problem of determining the minimum resource of means of destructive influence and their optimal distribution according to the goals of radio suppression and objects of destructive program influence to achieve the required level of disruption of the efficiency of information exchange in electronics systems. Based on the results of the article, a method has been developed for optimizing the distribution of the resource of radio suppression means and destructive program action for the development of possible scenarios for violation of information exchange by enemy in a typical electronics network. The verification of the proposed methodology was carried out by comparing the theoretical results with the results of simulation modeling of scenarios for violation of information exchange by an adversary in an electronics network.

Keywords: efficiency of information exchange, computer radio network, radio suppression, optimization of resource allocation.

Problem statement. Development of organizational and technical protecting methods of electronics network (EN). EN is extremely relevant in hybrid military actions. EN contains mobile and radio networks, computer tools of Tactical Management Element (TME) that are connected by means of protected radio lines in Local Computer Radio Network (LCRN) and integrated into global (regional) LCRM (typical EN).

Conducted researches shown that in conditions of hybrid military actions an enemy can influence the EN comprehensively, combining electronic influence on the lines of hub centers and communication lines of typical EN by means of Radio Suppression (RS) and Destructive Computer Impact (DCI) on elements of wireless computer networks.

Let's say, generally optimal scenario by certain criteria is developing for enemy's possible actions for violation of the efficiency of information exchange in EN.

Enemy can define potential objects of RS and DCI to conduct destructive influence on EN elements, which are characterized by weighting factor of protection from RS – k^{sws} and DCI – k^{nc}. In this case for destructive influence on data exchange enemy can use w^{mcsd} of DCI that solve the problem of destruction of data exchange in computer networks EN. For radio-suppression of RS and EN objects w^{dis} interference transmitters can be used.

We determine that for setting objectives it is considered only the case when enemy influence with the purpose of disrupt (violation of efficiency) of data exchange between subscribers (violation of "transportation" of information is considered). Then, let's assume that RS and DCI on EN elements leads to increasing of probability of info late "delivery" $P_{rs}^{ld}(t)$ regarding crisis situation to officials (bodies) of various levels of government.

As a resources required for appropriate scenario of RS and destructive software impact on the computer networks the following can be considered: additive number of Mobile Computer Suppression Device (MCSD) weighed on the coefficient of protection and designed to suppress various targets of DSI and interceptor transmitters on Unmanned Aerial Vehicle (UAVs), designed to radio suppression of EN hub centers, $R\left(w^{mcsd}, w^{dis}\right)$. During the research, it is necessary to solve the problem of optimal heterogeneous resource distribution of means of destructive influence on information exchange in EN on its elements in conditions of restrictions on efficiency indicator.

Analysis of recent research and publications. General questions of RS management and destructive software influence on computer networks are considered in [1] - [5] and [6]. Approaches to computer network modeling are outlined in [7] - [9]. However, the known results are not specified for solving problems of scenario approach application [4] in the development of methods of protection of EN from RS and DSI of the enemy, taking into account the indicators of violation of the efficiency of information exchange. Methodical approaches to the development of scenarios of complex RS and Electromagnetic Influence (EI) of typical EN are represented in [5]. It is concluded that on practice of conducting hybrid military operations, the enemy for RS NC and communication lines of typical EN can comprehensively use RS on Unmanned Aerial Vehicle Jammer (UAV-J), SNT, which bring Sabotage Reconnaissance Group (SRG) and to influence wireless computer networks – DSI [5]. When developing possible scenarios for the integrated usage of RS and DSI matters, the task of resource optimization of these matters and its distribution for the purposes of RP and object DPV arose.

Approaches for resource optimization of destructive influence on EN and the optimal distribution of RS and Destructive Software Impact (DSI) targets to achieve the required level of disruption of information exchange in EN are not developed in the foreign and domestic literature known to the authors.

The aim of this paper is to problem statement and development of resources optimization methodology for RS and DCI means in development of enemy influence scenarios on elements of typical EN.

The main material research. The simulation showed that in practice, in terms of radio-electronic protection of EN, the enemy needs to increase the number of used means of RS UAV-J, Small Noise Transmitter (SNT) and DCI (hereinafter – the resource) to achieve the required level of disruption of information exchange. Therefore, in order to achieve the aim of the article as a resource target function of appropriate scenario of RS and DSI on computer networks, it is advisable to consider a weighted additive number of DSIs designed to suppress different DSI targets nodal centers of typical EN.

$$R\left(w^{mcsd}, w^{dis}\right) = k^{sws} k^{pp} w^{mcsd} + k^{pnc} w^{dis}, \quad (1)$$

where $R\left(w^{mcsd}, w^{dis}\right)$ – resource spent by the enemy to implement the scenario RS NC EN and DSI on computer networks;

k^{sws} – weighting factor of security of workstations;

k^{pp} – weighting factor of protection of the purposes DCI;

w_{hv}^{mcsd} – number of embedded suppression devices that are implemented in WS;

k^{pnc} – weighting factor of protection of typical nodal centers EN;

w^{dis} – number of UAV-J, used to suppress nodal centers EN.

The question of determining the weights of the objective function (1) requires further scientific solution.

The analysis showed that for weight coefficient determination of extremum (1) it is possible to consider methods of approximating the utility function in generalized convolutions [10]. It is concluded that the known methods of pairwise comparisons, point estimates on the frequency scale, mainly determine the weights, which are difficult to use in generalized convolutions.

In this case, the methods of approximation of the utility function are used only when the utility function can be represented in additive form. Wherein weights coefficients are determined according to the contribution of the components to the overall utility.

However, weight coefficients calculated with these methods differ essentially from the weights coefficients k^{sws}, k^{pp}, k^{pnc} of protection of the goals of the RS, because the latter are not part of the efficiency function and, conversely, express the resistance of the goals of the RS to its growth. Then for weight coefficient k^{sws}, k^{pp}, k^{pnc} estimation k^{sws}, k^{pp} of protection of the goals of the RS can be used methods of pairwise comparisons, accurate estimates on a scale, frequencies of preferences of the person, but their use requires, as input data, expert information. In this situation, the solution lies in the field of complexing methods for determining weights and expert evaluation.

The analysis of the methods showed that the compromise option is to choose the method of frequencies of preferences of the decision maker using the Thurstone method [10]. This method requires only one expert (decision-maker), minimum communication time, minimum expert information (complete weighting) and can be used with a small number of estimated weights.

The essence of the method of frequencies of preferences of the decision-maker in relation to problem solve (1) is as follows. It is required to determine the weighting coefficients k^{sws}, k^{pp}, k^{pnc} of quality indicators "protection of Workstation (WS)" x^{sws}, "protection of the target of EN" x^{pp}, "protection of Nodal Center (NC) EN" x^{sws}, accordingly. For each of the defined groups of indicators there is a procedure consisting of the following stages:

1) a single ordinal scale is developed for all indicators so that the minimum quality for each indicator corresponds to the origin of the coordinates of the indicator space;

2) the decision maker compares all objects lying in each coordinate plane $x_i O x_j$, connecting them with arrows, and the arrows are placed from the best object to the worst;

3) counts the number of arrows directed from indicator *i* to indicator *j*, which characterizes the importance of indicator *i* in relation to indicator *j*. The total number of arrows will be the number of cases in which the indicator *i* is more important than the indicator *j*. Based on calculation results matrix $A = \|a_{ij}\|$ of Thurstone created; matrix *P* created the proportion of cases where the indicator *i* was more important than the indicator *j*: $P = \|p_{ij}\|, 1 \le i, j \le n$, where p_{ij} – the percentage of pairs of objects for which the arrow is "directed from criterion *i* to criterion *j*" and $p_{ij} = \frac{a_{ij}}{m}$, where $m = \frac{l^2\left(l^2 - 2l + 1\right)}{4}$ element of *P* matrix which corresponds to the condition $p_{ij} + p_{ji} = 1$. In

this model l – number of scores on the scales of indicators x_i and x_j and m – number of compared pairs in the plane Pk_iOPk_j;

4) p_{ij} is determined by iterative method and expressed in standard deviations:

$$p_{ij} = \int_{-\infty}^{z_{ij}} \frac{1}{\sqrt{2\pi}} e^{-z^2/2} dz, \tag{2}$$

5) calculates the "importance" of indicator *i*, expressed in standard deviations: $\bar{z}_i = \frac{z_i}{n}$, where $z_i = \sum_{j=1}^{n} z_{ij}$, Z_{ij} – unknown normalized variable.

6) probability p_i is calculated by formula (2) which corresponds to $\bar{z}_i$

7) rationing of p_i is carried out, and weighting coefficient k_i is determined.

Thus, the proposed method of frequencies of preferences of the decision maker allows to solve the problem of coefficients of protection determining of targets of RS and DSI, which can be used to optimize the distribution of resources needed for RS and DSI scenarios implementation on EN elements. The method requires a minimum time of communication with only one expert and a minimum of expert information.

The next important step in optimization goal is determination of constraints on the parameter of the objective function (1). According to the results of the simulation, it is determined that in practice RS and DSI on the elements of EN leads to increasing of probability of late information "delivery" regarding crisis by officials (bodies) of various levels of government. Figure 1 shows the graphs of the dependence of the probability $P_{rs}^{ld}(t)$ in different links of control on the intensity of interfering packets for different values of the number of WS in which the Destructive Software (DS) is implemented. Increasing the intensity of packets leads to probability increasing of late information receipt regarding crisis, and server suppression, server disruption is more effective in the lower management.

Graphs of the dependence of the probability of untimely "delivery" of information about the crisis situation on the number of WSs in which the DSI is implemented to suppress the server, Ethernet buses LCRN, are nonlinear. Therefore, when solving the problem of optimizing the resource allocation of RS and DSI EN, it is necessary to apply nonlinear methods.

Given the limitations on the volume of publication, we specify the least covered in the literature and researched in Ukraine issues of probability [5].

$$P_{rs}^{ld} = P(T^{ri} \le T^{ct}) = 1 - e^{-\beta}, \tag{3}$$

where β – intensity of information aging, $\beta = \frac{T^{ri}}{T^{ct}}$;

T^{ri} – time of receiving information about changes in the situation in the event of a crisis situation;

T^{ct} – critical time of delay of information about the crisis situation.

Methods for determining the parameter T^{ri} in each case are determined by the peculiarities of the construction of EN. In this case, EN can be formalized as a set of Queuing System (QS) – digital communication subsystems and computer networks [5].

When determining the parameter T^{ri} in the conditions of DSI on a typical EN computer networks should be modeled as a set of hierarchically integrated QS. To implement the proposed approach in [5] developed a methodological basis for mathematical modeling of DSI on computer networks EN, in which computer networks are presented as a set of hierarchically integrated QS, and implemented destructive software and radio suppression tools affect their operation through overload.

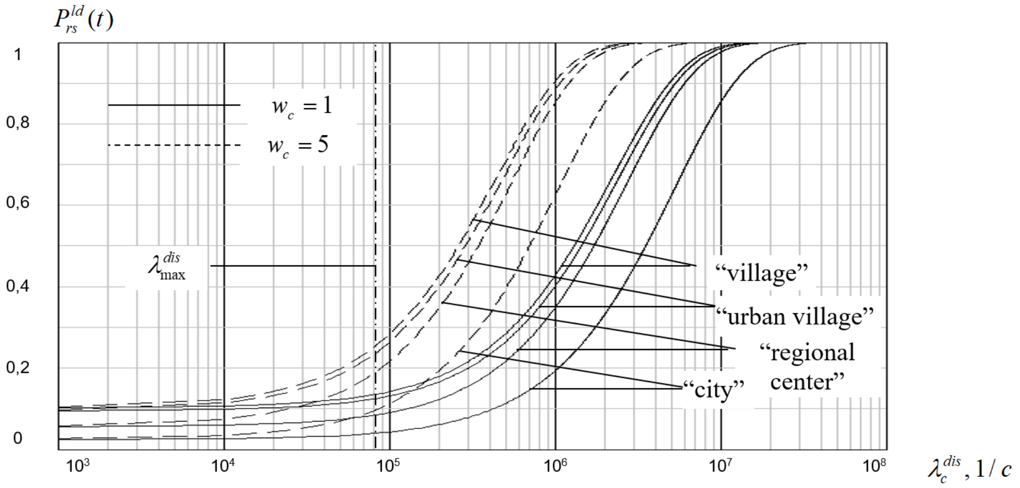

Figure 1 – Dependence of the probability of untimely "delivery" of information about the crisis situation in the management of "village", "urban village", "regional center", "city" from the intensity of interfering packets for different values of the number of WS of the computer network EN

The task of optimal distribution of the resource used for the implementation of the scenarios of the RS NC, communication lines and DSI on the computer networks of a typical EN, is specified as follows: to form a matrix: $W^{mcsd\ opt} = \left\| w_{hv}^{mcsd\ opt} \right\|, h = 1 \ldots H, v = 1 \ldots V$ the minimum number of DSI facilities that are implemented in the WS of local area networks in each *h* control link to suppress each *v* type of DSI targets, and the matrix: $W^{dis\ opt} = \left\| w_h^{dis\ opt} \right\|, h = 1 \ldots H$ in which H – number of management units in which the enemy solves the problem of disorganization and h – management unit number.

The minimum quantities of UAV-J, Small Interference Transmitter (SIT) used to suppress EN hub centers in each *h* link, which ensure compliance with the criterion of efficiency of RS and DSI $P_h^{pui} \geq P_{nec}^{pui}$, taking into account the weights of RS protection k_h^{pws}, DSI goals k_v^{pp} and nodal centers, EN communication lines (4). It should be noted that P_h^{pui}, P_{nec}^{pui} – probability of untimely receipt of information about the crisis situation in *h*-d chain of government and its necessary importance for the disorganization of public administration, respectively.

$$S^{opt} = \arg\min\left\{ R_h\left(w_{hv}^{mcsd}, w_h^{dis} \right) \right\}, \tag{4}$$

where $R_h\left(w_{hv}^{mcsd}, w_h^{dis} \right)$ – function of the resource used to implement the method of radio suppression and destructive software effects on computer networks in *h*-d element of management; $r_{hv}\left(w_{hv}^{mcsd}, w_h^{dis} \right)$ – *hv*-d component of the resource function.

$$R_h\left(w_{hv}^{mcsd}, w_h^{dis} \right) = \sum_{v=1}^{V} r_{hv}\left(w_{hv}^{mcsd}, w_h^{dis} \right) = \sum_{v=1}^{V} k_h^{sws} k_v^{pp} w_{hv}^{mcsd} + k_h^{pnc} w_h^{dis},\ h = 1 \ldots H,\quad v = 1 \ldots V \tag{5}$$

where k_v^{pp} – weighting factor of protection of the purposes DCI *v*-d type;

w_{hv}^{mcsd} – number of embedded suppression devices that are implemented in WS in each local area networks *h* element of management to suppress each *v* type of goals DSI;

w_h^{dis} – number of UAV-J, used to suppress nodal centers EN in each *h* element of management;

k_h^{pws} – weighting factor of protection WS in *h*-d element of management at introduction DSI;

k_h^{pnc} – weighting factor of protection NC mesh EN in *h*-d element of management.

with restrictions:

$$P_h^{pui}\left(w_{hv}^{mcsd}, w_h^{dis} \right) \geq P_{nec}^{pui}, \tag{6}$$

$$w_{hv}^{mcsd} \in \left\{ 0, 1, 2, \ldots, N_{ws} \right\},\quad w_h^{dis} \in \left\{ 0, 1, 2, \ldots, N_h^{nc} \right\},\ h = 1 \ldots H,\quad v = 1 \ldots V \tag{7}$$

Problem (2) - (6) is the problem of determining the minimum required resource to ensure the value of the multiplicative objective function of arbitrary form not less than the specified one. Analysis of methods of optimal resource allocation [11], which can be solved by the method of successive increments [11].

The method of successive increments allows you to effectively solve problems such as: find a series $X^o = \left\{ x_i^o \right\}_n = \min_{x_i} \left\{ x_i \right\}_n = \min_{x_i} \sum_{i=1}^{n} x_i$, which provides the value of the additive function not less than the specified:

$$F\left(X\right) = \sum_{i=1}^{n} F_i\left(x_i\right) \geq F^{giv}\left(X\right), \tag{8}$$

with a linear constraint on the variable:

$$\left(X = \sum_{i=1}^{n} x_i\right) \leq b, \quad b > 0, \tag{9}$$

whole provided they are integer and integral:

$$x_i \in \left\{0, 1, 2, \ldots, b\right\}, \quad i = 1, 2, \ldots, n. \tag{10}$$

To bring the problem (2) - (6) to the conditions (7) - (9) it is necessary to ensure the additive nature of the objective function, the independence of its components, as well as the transition from variables w_{hv}^{mcsd}, w_h^{dis} to function $R_h\left(w_{hv}^{mcsd}, w_h^{dis}\right)$.

Fulfillment of the additivity condition of the target function will be ensured by the transition from the function of the probability of untimely receipt of information about the crisis situation to the function of the time of obtaining information about the operational and tactical situation, which is additive. Then, we get the objective function:

$$T_h^{ri}\left(w_{hv}^{mcsd}, w_h^{dis}\right) = T_{h-1}^{ri} + \sum_{v=1}^{V} \overline{T}_{hv}\left(w_{hv}^{mcsd}, w_h^{dis}\right) \geq -T_h^{ct} \ln\left(1 - P_{nec}^{pui}\right), \quad h = 1 \ldots H, \tag{11}$$

where $T_h^{ri}\left(w_{hv}^{mcsd}, w_h^{dis}\right)$ – time of receiving information about the operational and tactical situation в h-d element of management;

T_{h-1}^{ri} – time of receiving information about the crisis situation in the relevant level of management, in which it achieves the criterion of suppression efficiency;

$\overline{T}_{hv}\left(w_{hv}^{mcsd}, w_h^{dis}\right)$ – the average processing time of the transaction data in the target DSI v-d type in h-d element of management;

T_h^{ct} – time of aging information about the crisis situation in h-d element of management.

In cases where some components $\overline{T}_{hv}\left(w_{hv}^{mcsd}, w_h^{dis}\right)$ of the objective function are dependent, it is advisable to move to their combinations, which are formed by successive search of the values of one parameter with a fixed second parameter, while the formed components will be independent.

Since for each value w_{hv}^{mcsd}, w_h^{dis} the values of $T_h^{ri}\left(w_{hv}^{mcsd}, w_h^{dis}\right)$ and $R_h\left(w_{hv}^{mcsd}, w_h^{dis}\right)$ are known, then, assuming the value R_h to be independent, it is possible to assume that the value of the function $\Theta_h\left(R_h\right)$ is also known, because it is equal to the value $T_h^{ri}\left(w_{hv}^{mcsd}, w_h^{dis}\right)$. Thus, the set of values of the function $T_h^{ri}\left(w_{hv}^{mcsd}, w_h^{dis}\right)$ is uniquely reflected in the set of values of the function $\Theta_h\left(R_h\right)$, which provides a transition from variables to functions:

$$T_h^{ri}\left(w_{hv}^{mcsd}, w_h^{nc}\right) = T_{h-1}^{ri} + \sum_{v=1}^{V} \overline{T}_{hv}\left(w_{hv}^{mcsd}, w_h^{nc}\right) = T_{h-1}^{ri} + \sum_{v=1}^{V} F_{hv}\left(w_{hv}^{mcsd}\left(R_h\right), w_h^{nc}\left(R_h\right)\right) = T_{h-1}^{ri} + \sum_{v=1}^{V} \theta_{hv}\left(r_{hv}\right) = \Theta\left(R_h\right), \tag{12}$$

where $\theta_{hv}\left(r_{hv}\right)$ – hv-d component of the transformed objective function.

Then, taking into account (8) - (12), problem (4) - (7) will take the form:

$$S^{opt} = \arg\min\left\{R_h\left(w_{hv}^{mcsd}, w_h^{dis}\right)\right\}, \tag{13}$$

$$R_h\left(w_{hv}^{mcsd},w_h^{dis}\right)=\sum_{v=1}^{V}r_{hv}\left(w_{hv}^{mcsd},w_h^{dis}\right)=\sum_{v=1}^{V}k_h^{pws}k_v^{pp}w_{hv}^{mcsd}+k_h^{pnc}w_h^{dis},\ h=1\ldots H,\quad v=1\ldots V \tag{14}$$

with restrictions:

$$\Theta_h\left(R_h\left(w_{hv}^{mcsd},w_h^{nc}\right)\right)\geq -T_h^{ct}\ln\left(1-P_{nec}^{pui}\right), \tag{15}$$

where $\theta_h\left(R_h\right)$ – converted objective function.

$$w_{hv}^{mcsd}\in\left\{0,1,2,\ldots,N_{ws}\right\},\quad w_h^{dis}\in\left\{0,1,2,\ldots,N_h^{nc}\right\},\ h=1\ldots H,\quad v=1\ldots V, \tag{16}$$

where N_h^{nc} – number of NC mesh EN in *h*-d element of management.

For optimization we will use the process of sequential allocation of resources w_{hv}^{mcsd}, w_h^{dis} in some portions $\Delta w_{hv}^{mcsd(t)}, \Delta w_h^{dis(t)}$, respectively, in the *t*-th step of the process. If at the *t*-th step of the process the argument of the *hv*-th component of the resource function gets an increment $\Delta w_{hv}^{mcsd(t)}, \Delta w_h^{dis(t)}$, it will get the increment of the $\Delta r_{hv}^{(t)}$ *hv*-th component of the resource function and, accordingly, the converted objective function:

$$\Delta\Theta_h\left(R_h^{(t)}\right)=\Delta\theta_{hv}\left(r_{hv}^{(t)}\right)=\theta_{hv}\left(r_{hv}^{(t-1)}+\Delta r_{hv}^{(t)}\right)-\theta_{hv}\left(r_{hv}^{(t-1)}\right)=\Delta\theta_{hv}, \tag{17}$$

The average efficiency of each of the resource units at the *t*-th step of the process is determined by the ratio:

$$e_{hv}^{(t)}=\frac{\Delta\theta_{hv}\left(r_{hv}^{(t)}\right)}{\Delta r_{hv}^{(t)}},\quad h=1\ldots H,\quad v=1\ldots V, \tag{18}$$

The optimal algorithm will be a sequential distribution of the resource in portions $\Delta r_{hv_t}^{(t)}$, the value and index hv_t which are determined in accordance with the maximum efficiency of use of each unit of resource at each step of the process.

The optimal step size $\Delta r_{hv}^{(m)}$ is determined by the condition:

$$\left(e_{hv}^{(m)}=\frac{\Delta\theta_{hv}^{(m)}}{\Delta r_{hv}^{(m)}}\right)=\max_{\Delta r_{hv}}\left(e_{hv}=\frac{\Delta\theta_{hv}}{\Delta r_{hv_t}}\right),\ h=1\ldots H,\quad v=1\ldots V, \tag{19}$$

The index hv_t of the component of the resource function, at which the *t*-th step of the process achieves the largest value $e_{hv}^{(m)}$, is determined in accordance with the condition:

$$e_{hv_t}^{(m)}=\max e_{hv}^{(m)},\quad h=1\ldots H,\quad v=1\ldots V. \tag{20}$$

The result is a matrix: $W^{mcsd\ opt}=\left\|w_{hv}^{mcsd\ opt}\right\|,\quad W^{dis\ opt}=\left\|w_h^{dis\ opt}\right\|,\ h=1\ldots H, v=1\ldots V$ which form the optimal distribution of resources used to implement the scenarios of RS and DSI of the enemy on EN.

Thus, the method of sequential increments allows you to optimize the distribution of resources used to implement methods of radio suppression and computer exposure to EN.

Experiments. According to the results of the simulation, it is concluded that in practice RS and DSI on the elements of EN leads to increasing of probability late "delivery" of information regarding crisis in a special period by officials (bodies) of various levels of government.

It was received the dependencies of untimely "delivery" of information regarding crisis in management of "village", "urban-type settlement", "regional center", "city" from the intensity of interfering packages. Wherein number of WS of EN with implemented DCIs were 1 and 5 accordingly. Intensity of interfering packets ranged from 10^3 to $10^{8.}$ It is concluded that increasing the intensity leads to increasing of probability of untimely receiving of information regarding crisis, whereby suppression of server, disruption of servers is more effective in the lower levels of management.

Results. It was conducted task settlement of RS and DSI resource optimization during developing scenarios of enemy influence on the elements of a typical EN. To determine the coefficients of protection of objects of electronic influence and destructive computer influence of the target additive function, the method of frequencies of preferences of the decision-maker combined with the method of Thurstone was used. The research showed that to solve the problem of optimal distribution of the heterogeneous resource of destructive influences in conditions that the value of the multiplicative objective function of an arbitrary form is not less than a given, method of successive increments is used. Wherein to determine the rate of efficiency of information exchange violations, the methods of queuing theory are used, which allows to formalize electronics systems as a set of queuing systems – digital communication subsystems and computer networks. According to the results of the simulation, it is concluded that in practice RS and DSI on the EN elements leads to increasing probability of late "delivery" of information regarding crisis by officials (bodies) of various levels of government.

Discussion. The results obtained in the article are the development of a scenario approach in the field of forecasting possible actions of the enemy to disrupt the efficiency of information exchange. For development of scenarios of RS and DSI on EN elements the mathematical apparatus of the theory of optimal resource distribution in the conditions of nonlinearity of the additive resource function is applied. Additional restrictions on the resource target function due to the achievement of the required violation of the efficiency of information exchange in EN were taken into account.

The peculiarity of additive objective function in the development of scenarios of RS and DSI of EN elements is the necessity to take into account the protection coefficients of the respective elements of EN, which are targets of RS and DSI. The solution of this problem can be reached by the method of frequencies of preference of the decision maker using the Thurston method [10]. This method requires only one expert (decision maker), minimum communication time, minimum expert information (complete ordering of weights coefficients) and can be used with a small number of estimated weights coefficients.

To fulfill the additivity condition of the target function will be provided by the transition from the probability function of late receipt of information regarding crisis situation to the time function of obtaining information about the operational and tactical situation, which is additive. Thus, for definition of the minimum necessary resource for maintenance of value of a multiplicative objective function of an arbitrary kind not less than set, the method of consecutive increments is applied. The developed methods are specified to the level of algorithms and can be used in engineering calculations of the efficiency of information exchange in EN.

Conclusions. The scientific novelty of the results of the research lies in the improved method of optimizing the resource allocation of radio suppression and destructive software impacts for the development of possible scenarios for the enemy's violation of information exchange in a typical EN. The developed method differs from the known ones that for the first time account in development of scenarios of destructive impact on EN it was taken into account the complex usage by enemy of RS and destructive software impact. The practical significance of the research results is that the developed methods allow to determine in practice the minimum set of tools of RS and DCI, which provides the required level of violation of the efficiency of information exchange in various levels of government. The developed methods are concretized to the level of algorithms, which simplifies their further implementation of applied software products that can be used in the development of scenarios of the enemy to disrupt public administration. The results obtained in the article are normalized and can be used in engineering calculations of the efficiency of information exchange in EN and in assessing the signal-interference situation.

Prospects for further research in this area are to develop a theoretical basis for determining scenarios of possible actions of the enemy in terms of integrated usage of RS, electromagnetic and computer effects on the elements of EN.

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ОПТИМІЗАЦІЯ РОЗПОДІЛУ РЕСУРСУ ЗАСОБІВ РАДІОПОДАВЛЕННЯ ТА ДЕСТРУКТИВНОГО ПРОГРАМНОГО ВПЛИВУ НА ЕЛЕКТРОННІ КОМУНІКАЦІЙНІ МЕРЕЖІ

Досліджено методичні підходи до розробки сценаріїв комплексного радіоподавлення та електромагнітного впливу на типові електронні комунікаційні системи. Водночас, при розробці можливих сценаріїв комплексного застосування засобів радіоподавлення та деструктивного програмного впливу виникла задача оптимізації ресурсу цих засобів та його розподілу по цілях радіоподавлення та об'єктах деструктивного впливу. Ця задача не вирішена у повному обсязі. Тому, необхідно провести її постановку та розробити методику оптимізації розподілу ресурсу засобів радіоподавлення та деструктивного програмного впливу з урахуванням можливих сценаріїв порушення противником інформаційного обміну в типовій електронній комунікаційній мережі. Метою дослідження є вдосконалення методики оптимізація розподілу ресурсу засобів радіоподавлення та деструктивного програмного впливу для розробки сценаріїв порушення противником інформаційного обміну в електронній комунікаційній мережі. Це досягнуто застосуванням методів нелінійної оптимізації розподілу різнорідного ресурсу. Для визначення коефіцієнтів захищеності об'єктів радіоелектронного впливу та деструктивного впливу використано метод частот переваг особи, що приймає рішення із застосуванням метода Терстоуна. Задачу оптимального розподілу різнорідного ресурсу засобів деструктивного комп'ютерного впливу при забезпеченні значення мультиплікативної цільової функції довільного вигляду не менше заданого вирішено методом послідовних прирощень. При цьому, з метою визначення показника оперативності порушення інформаційного обміну застосовано методи теорії масового обслуговування, що дозволяє формалізувати електронні комунікаційні системи як сукупність підсистем масового обслуговування – цифрового зв'язку та комп'ютерних мереж. Здійснена постановка задачі та введені показники дозволили визначити мінімальний ресурс засобів деструктивного впливу та оптимальний розподіл їх по цілях радіоподавлення та об'єктах деструктивного програмного впливу для досягнення потрібного рівня порушення оперативності інформаційного обміну у електронних комунікаційних системах. За результатами розроблена методика оптимізації розподілу ресурсу засобів радіоподавлення та деструктивного програмного впливу з метою формування можливих сценаріїв порушення противником інформаційного обміну у типовій електронній комунікаційній мережі. Перевірку запропонованої методики здійснено шляхом порівняння теоретичних результатів з результатами імітаційного моделювання сценаріїв порушення противником інформаційного обміну в електронній комунікаційній мережі.

Ключові слова: оперативність інформаційного обміну, комп'ютерна радіомережа, радіоподавлення, оптимізація розподілу ресурсу.

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