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Model of Dynamic Management of Telecommunication and Computer Resources

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Abstract

The document identified the problem and developed a model of the dynamic management of telecommunication and computer resources. The present level of development of information and telecommunication technologies, the improvement of communication and their integration into the high-performance human-machine systems administration cause the creation of a single information and telecommunication space of mobile units. The work is devoted to consideration of bases of research of a set of tasks of tactical management of information security. Presents direct and inverse problems and solution methods.

Keywords: management of telecommunications and computing resources, mathematical model, optimization, the volume of tasks, the distribution plan telecommunications, the direct problem, inverse problem, dynamic programming, objects of application, information packages.

Introduction

The present level of development of information and telecommunication technologies, the improvement of communication and their integration into the high-performance human-machine systems administration cause the creation of a single information and telecommunication space of mobile units (air, water, rail and road). In these circumstances, particularly relevant get management tasks information and computer resources that can provide the optimal distribution of computing and telecommunications facilities in use.

Materials and Methods

This problem belongs to the main tasks of tactical management use of computer systems (marketing objectives). Each resource telecommunications should be appropriate divided between "real use" on the criterion of a minimum delivery time information packets.

Overall, the model can be represented as follows:

The volume problems for directions tons connection –

$$V = \langle v_j, j = \overline{1,n} \rangle. \tag{1}$$

Specific problems for volume 1 resource unit (r.u) product i ($i = \overline{1,m}$) and the second types j ($j = \overline{1,n}$) direction –

$$A = \| a_{ij} \|_{m \times n}; \tag{2}$$

unit costs (monetary units - th) performed on one task r.u i - th and second means for the j-th direction -–

$$C = \| c_{ij} \|_{m \times n}. \tag{3}$$

Telecommunications distribution plan is the matrix –

$$X = \| x_{ij} \|_{m \times n}, \tag{4}$$

where x_{ij} - the number of problems and of type intended for the j-th direction.

There was a next (inverse) problem of optimal distribution of diverse products - on the set of allocation plans *{X}*, each of which *X* satisfies the restrictions on the right traffic information –

$$\sum_{i=1}^{m} a_{ij} x_{ij} \geq v_j, \; j = \overline{1,n}, \tag{5}$$

find an optimal plan

$$X^o = \| x_{ij}^o \|_{m \times n}, \tag{6}$$

which minimizes the total cost of solving

$$CS(X^o) = \min_{\{X\}} CS(X) = \sum_{j=1}^{n} \sum_{i=1}^{m} c_{ij} x_{ij}^o. \tag{7}$$

This requires telecommunications will park –

$$\sum_{j=1}^{n} x_{ij} = B_i, \; i = \overline{1,m}. \tag{8}$$

If an existing park telecommunications is a vector –

$$B = \langle b_i, i = \overline{1,m} \rangle, \tag{9}$$

there is a "direct" problem of optimal distribution of different types of telecommunications - plans for distribution on the set *{X}*, each of which satisfies the *X* limit –

$$\sum_{j=1}^{n} x_{ij} \leq b_i, \; i = \overline{1,m}, \tag{10}$$

find an (optimal) plan

$$X^o = \| x_{ij}^o \|_{m \times n}, \tag{11}$$

which maximizing the total volume of tasks

$$VS(X^o) = \max_{\{X\}} VS(X) = \sum_{j=1}^{n} \sum_{i=1}^{m} a_{ij} x_{ij}^o . \quad (12)$$

This volume telecommunications up –

$$\sum_{i=1}^{m} a_{ij} x_{ij} = V_j , i = \overline{1,n} . \quad (13)$$

Previously, it was found that the nature of production functions "effect-cost" is determined not only by the number of means (main resource) and their group performance (convex functions), and sometimes uncontrollable factors (dependence of demand on the number of vehicles) that make tool "not convex ". That is what defines a formal statement of the problem of distribution and selection of suitable mathematical programming methods for their correct solution [1-15].

Suppose there are n objects of this class resource use telecommunications to the "production" functions (cost-effect), which is the "logistics" and because they "do not bulge," Transcendence or uneven discrete set of statistical argument set pairs "argument function" with interpolation, such as "splines" [2].

The method of regression analysis or "trend" every logistics function is a polynomial of 3rd degree - the calculation formula for calculating its values at discrete (integer) argument. As a result of the application of the system of objects can be done to a table of values logistic functions for integer values of the argument –

Wj (k) = (14)

	Wi	..	*Wj*	..	*Wn*
x=i	*wi(i)*	..	*wj(i)*	..	*wn(i)*
...	...	..	...	..	...
x=k	*wi(k)*	..	*wj(k)*	..	*wn(k)*
...	...	..	...	..	...
x=xmax	*wi(xmax)*	..	*wj(xmax)*	..	*wn(xmax)*

This is obviously the maximum number of resource units that can be distributed in the system object is –

$$NS_{\max} = n \times x_{\max} , \quad (15)$$

and the maximum overall effect will be –

$$WS_{\max} = \sum_{j=1}^{n} w_j (x_{\max j}) . \quad (16)$$

Valid allocation plan means the objects are the vector –

$$X(NS) = \left\langle x_j , j = \overline{1,n} \right\rangle , \quad (17)$$

for which each component is within the convoy –

$$(0 \le x_j \le x_{\max j}), j = \overline{1,n}, \ \sum_{j=1}^{n} x_j = NS, \ (0 \le NS \le NS_{\max}) , \quad (18)$$

and systemic effect in this regard is provided "separable" (which is additive) effects of partial function –

$$WS\{X(NS)\} = \sum_{j=1}^{n} w_j (x_j) . \quad (19)$$

Exhaustive set of feasible allocation plans *{X}* gives a certain area on the coordinate plane *WoN*, and each *X* correspond to the distribution plan, as it coordinates expenses *NS (X)* and the effect of *WS (X)*.

But only plans that form a "top left" border region of feasible solutions, is the set of optimal solutions - Pareto *{Xo}*. Indeed, among the solutions that the "equivalent" to the *X* on the effect of *WS (X)* (horizontal dotted line), the best is a decision that belongs to the "left" landmark region *{X},* because requires minimal compared with *NS (X),* costs among the solutions that the "equivalent" to the *X* expenditure *NS (X)* (vertical dotted line), the best is a decision that belongs to the "top" landmark region *{X},* for giving the maximum, compared to *WS (X*o), effect.

Analysis of typical graphics Pareto function *{X}* [3] (the set of optimal solutions that forms a continuous curve red in Fig. 1) shows that the optimal allocation of resources («point» *Xo*) is almost enough ("core") systemic effect –

$$WS(X^{o}) \approx (0.75 \div 0.85) \times WS_{\max} \qquad (20)$$

achieved relatively minor (partial) cost –

$$NS(X^{o}) \approx (0.35 \div 0.45) \times NS_{\max}, \qquad (21)$$

and further increase system costs only leads to a significant reduction in their "group" because of falling productivity growth systemic effect.

This means that the "primary" task of optimal distribution means the objects are "inverse" problem - on the set *{X}* general-numerical allocation plans, each of which meets the required level restriction effect

$$WS(X) = \sum_{j=1}^{n} w_j(x_j) \geq WS^{nomp}, \qquad (22)$$

find an (optimal) plan – vector

$$X^{o} = \left\langle x_j^{o},\ j = \overline{1,n} \right\rangle, \qquad (23)$$

which minimizes the total cost of the resource –

$$NS(X^{o}) = \min_{\{X\}} NS(X) = \sum_{j=1}^{n} x_j^{o}. \qquad (24)$$

If necessary, "concessions" may be decided to limit the secondary "direct" problem of optimal allocation of means on objects - on the set *{X}* general-numerical allocation plans, each of which meets the permissible limits on resource costs.

$$NS(X) = \sum_{j=1}^{n} (x_j) \leq NS^{npun}, \qquad (25)$$

find an (optimal) plan – vector

$$X^{o} = \left\langle x_j^{o},\ j = \overline{1,n} \right\rangle, \qquad (26)$$

maximizing the overall effect –

$$WS(X^{o}) = \max_{\{X\}} WS(X) = \sum_{j=1}^{n} w_j(x_j^{o}). \qquad (27)$$

All of this – the dynamic programming problem solved adapted (minimized to providing solutions to problems of resource distribution) by "pyramidal Tables" [1-15].

The procedure is dynamic programming successive stages of conditional and unconditional optimization. Step conditional optimization is to determine the potential of all the "states" and relevant to them conventional stepper optimal resource allocation plans $R_i^{o}(k) = \left\langle r_i^{0}, (k - r_i^{o}) \right\rangle, i = \overline{(m-1),1}$

for each object, starting from the last T1 Those finishing first, with recurrent expression - functional Bellman [1-2] to additive effect –

$$W_i(k_i, r_i^o(k_i)) = \max_{\substack{r_i = \overline{0,k_i} \\ k_i = \overline{0,N_i}}} \left\{ w_i(r_i) + W_{i+1}(k_i - r_i) \right\}, \; i = \overline{(m-1)},$$

где (28)

$$N_i = r\max_i + N_{i+1} = r\max_i + (r\max_{i+1} + \ldots + r\max_n), \; i = \overline{(m-1)}.$$

Graphical interpretation of the functional Bellman and optimal resource allocation plan stepper given in Fig. 1.

It provided (for ease of understanding) isometric coordinate system to display the tool Bellman {#} in functionality (28).

The first component amounts $w_i(r_i)$ – it is stepping effect and the second object - set the schedule on the "left vertical" coordinate plane; the second component amounts $W_{i+1}(k - r_i)$ – it is the total effect to the objects of the *(i + 1)* th to *m*-th (at best "stepper" distribution plan *(k-rᵢ)* bus resource) - the flight schedules of the "right vertical" coordinate plane; set $R_i(k) = \langle r_i, (k - r_i) \rangle$ possible plans for the allocation of resources between the *i*-th object and the rest of the *(i + 1), ..., m* and objects for the first step - direct *k*, which schedule provided in the horizontal (bottom) coordinate plane. When fingering set allocation plans *w, k* resource, according to (14), each of which corresponds to the "projection" on axis (r_i), where there is a "stepping" effect (ordinate the arrow), and projection on the axis *(k-rᵢ),* in which there is an effect for the rest of the objects $W_{i+1}(k - r_i)$ ordinate which also shows the arrow.

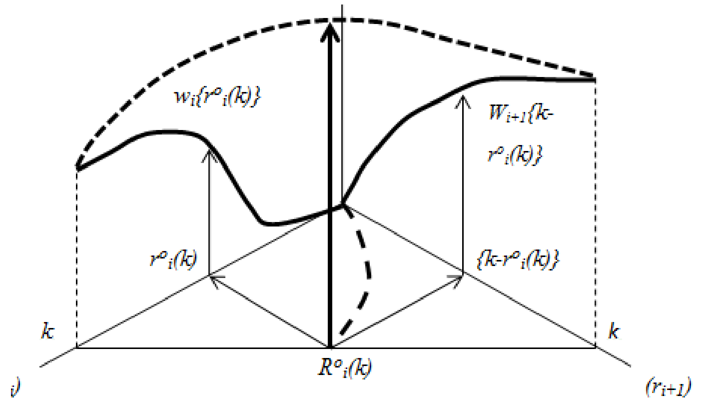

Figure 1. Functional Bellman and optimal resource allocation plans for stepping on and *i*-step

The amount of data ordinates according compilation in {#} equals applicator w_i *(k),* which is provided with an arrow "points" $R_i(k)$. Obviously, the set of plans along the line *k* gives the applicant the set, which are values Bellman functions for allocation plans $\{R_i(k)\}$ and owned a vertical plane, which has a *k* line its intersection with the horizontal plane. Thus, the set of the function Bellman ($w_i k_i$) forms a "curve" (shown in bold dotted line), which has a maximum value for optimal distribution plan – the point $R_i^o(k) = \langle r_i^0, (k - r_i^o) \rangle$.

From this value, according to (14), is the "potential" (meaning functional Bellman) for the value of the argument *k*; enumeration values $k = \overline{0, N_i}$ allows to go all the meaning of "potential" and for the first step - they provided a thick dotted line in the horizontal plane of the coordinate (of origin). Thus, above the horizontal coordinate plane there is a "two-dimensional" function Bellman, serial section whose vertical plane for variable argument value k determine the appropriate maxima of the features that are functional Bellman values. A look at Fig. 1 "from above" on a horizontal coordinate plane, can interpret two-dimensional "surface" function Bellman over it as its "numerical terrain" of the applicant to the "pyramid" area of the horizontal coordinate plane. As a result, there is a matrix of conditional optimization optimal conventional stepper offices –

$$R^{o} = \left\| r_{ij}^{o} \right\|_{M \times N}, \tag{29}$$

and on her Pareto function [1] system for functional objects as one step conditional optimization *Wi (k).*

Step unconstrained optimization is to find the matrix *Ro* vector unconditional stepper optimal distribution plan offices as $k = N$, m units of resources between objects –

$$R^{o}(N) = \left\langle r_{1}^{o}, \ldots, r_{i}^{o}, \ldots, r_{m}^{o} \right\rangle. \tag{30}$$

Suppose you want to find an optimal plan distribution of resources between units *N, m* objects of their application, which provided the tool "FX expenses" in numerical form –

$$\{w_{i}(k), k = \overline{0, r_{\max}}\}, i = \overline{1, m}. \tag{31}$$

Provide general scheme of procedures for conditional stages (upper band) in absolute (lower band) *SE* optimization problem (Fig. 2). At each step, using a "pyramid" interpretation coordinate plane bearing numerical terrain features Bellman.

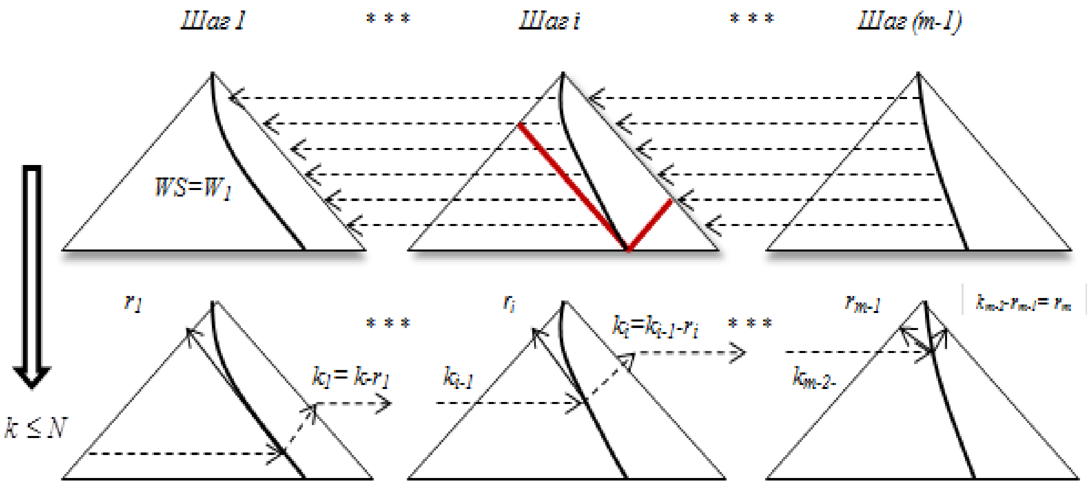

Figure 2. The scheme conditional stages (upper band) in absolute (lower band) optimization problem in SE

Solving problems of resource optimization classical method of dynamic programming, which is globally exact requires, unfortunately, a significant investment of computational resources (RAM and number of transactions ordered busting) for computers. Note that the conditional optimization procedure can be reduced repeatedly ordered bust at each step only values of the argument of the function of each partial effect, which are the coordinate elements when calculating potentials (in Fig.2 for the *i*-th step shown gray line). Significant reduction of required calculations and computer memory is achieved based on actual values of function arguments "effect-cost" objects. Since the maximum value argument for each partial function is limited –

$$r\max_{j} \leq NS, \; j = \overline{1, m}, \tag{32}$$

the reduction of conditional optimal search area departments on Bellman for all objects in all steps will be (times) –

$$\delta = \left\{ \sum_{j=m-1}^{1} N \cdot (n/2) \right\} \Bigg/ \left\{ \sum_{j=m-1}^{1} r\max_j \cdot (N_m - r\max_j) \right\}, \quad (33)$$

where *Nj* - accumulated the *j*-th step the sum of the maximum values of *r*, equal

$$N_j = r\max_j + N_{j+1}, N_m = r\max_m, j = \overline{(m-1),1}. \quad (34)$$

The analysis shows that winning this procedure compared to existing performance and the desired memory appears multiple computers.

Discussion

Thus, the solution to the problem of distribution facilities by means of force application completely defines the number of members on the types of assets that is required for the formation inflicted systemic effect. This - the first stage of determining the basic composition of forces and the forces of application software for the system. The composition of assets derived data to solve the problem further distribution of forces for tasks (events) application process. Solving problems of resource optimization classical method of dynamic programming, which is globally exact, requires, unfortunately, a significant investment of computational resources (memory volume and number of transactions ordered busting) for computers.

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Модель динамического управления телекоммуникационными и компьютерными ресурсами

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Аннотация. Современный уровень развития информационных и телекоммуникационных технологий, улучшение коммуникаций и их интеграции в высокоэффективных человеко-машинных систем управления предусматривает создание единого информационного и телекоммуникационного пространства мобильных подразделений. В документе определены задачи и разработана модель динамического управления телекоммуникационных и компьютерных ресурсов. Работа посвящена рассмотрению основ исследования комплекса задач тактического управления информационной безопасностью. Представлена прямых и обратная задачи, а так же методы их решения.

Ключевые слова: управление телекоммуникационными и вычислительными ресурсами, математическая модель, оптимизация, объем задач, распределение плана телекоммуникаций, прямая задача, обратная задача, динамическое программирование, объекты применения, информационные пакеты.