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INFORMATION RESOURCES DISTRIBUTION BETWEEN AUTOMATED WORKSTATIONS IN LOCAL CORPORATIVE NETWORKS

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This article focuses on the problem of optimal distribution of related information resources between automated workstations in local corporate networks. In this work we present a mathematical description of the algorithm for quasi-optimal distribution of related information resources at designing automated workstations in a local corporate network. The undirected graph describing the task of information resources optimal distribution is presented. The method of quasi-optimal distribution of related resources at designing automated workstations in the local corporative network is proposed based on the developed algorithm. Using conditional organization as an example the modeling of optimal distribution of related information resources has been considered in local corporative network. The described algorithm provides an opportunity to optimally distribute the information resource in the local corporate network, as well as solve the task of building reliable and efficient local networks. The proposed method of quasi-optimal distribution of related information resources can be used in corporation of any type.

Keywords: data distribution, local networks, quasi-optimal distribution algorithm, automated workstations..

В статті розглядається проблематика оптимального розподілу пов'язаних інформаційних ресурсів між автоматизованими робочими станціями в локальних корпоративних мережах. В роботі представлено математичний опис алгоритму квазіоптимального розподілу пов'язаних інформаційних ресурсів при проектуванні автоматизованих робочих станцій в локальній корпоративній мережі. Наведено граф опису задачі оптимального розподілу ресурсів. На підставі розробленого алгоритму пропонується методика квазіоптимального розподілу пов'язаних ресурсів при проектуванні автоматизованих робочих станцій в локальній мережі організацій. Здійснено моделювання оптимального розподілу інформаційних ресурсів на прикладі умовної організації. Використання описаного алгоритму дозволяє оптимально розподіляти інформаційний ресурс в локальній корпоративній мережії, а також вирішувати питання побудови локальних мереж з високою надійністю та ефективністю використання. Запропонована методика квазіоптимального розподілу пов'язаних інформаційних ресурсів може застосовуватися в організаціях будь-якого рівня.

Ключові слова: розподіл даних, локальні мережі, алгоритм квазіоптимального розподілу, автоматизовані робочі станції.

Introduction

At present, the most peculiarities in corporations activity are the wide use of IT and the effective distribution of information resources within their organizational structures [1, 2]. Networking distributed technologies with high bandwidth are becoming the main channels for the exchange of goods and services contributes to the emergence of new business structures, which through information network system establish partnerships and carry out their economic activities [3, 4]. Most modern applied information technologies that used in business are based on distributed systems of information processing [5-8]. Currently, we can observe a tendency to allocate and decentralize computing resources.

The use of distribution of related information resources network technologies in everyday business has become a norm for western companies. The distributed network technologies are used not only for messaging and for access to information resources, but also for carrying out specific commercial transactions. The development of such technologies helps to reduce costs, accelerate all business processes and, as a result, increase the profitability of the company's operations. The high-technologies degree and practical implementation of network technology of distribution of related information resources in any modern enterprise considerably determines its success on electronic market. The level of distributed network application directly determines the competitiveness of its goods and services.

Manufacturing companies of hardware and software have been the first to use the distributed network technologies at goods and services marketing and distribution. An example of successful development of many of them has become a factor of attractiveness for businesses operating in other areas. Accumulated experience of distribution of related information resources network technologies is generalized, even the scientific researchers are conducted and materials are published [1, 3, 5, 6].

The technological aspects of modern economic activity of corporations are extremely important factors that ensure the effectiveness of its operation. The reliability, safety of technological solutions are the basis of economic activity, which depends on the effective distribution of related information resources. The current level of technology development allows creating high-performance, protected from external interference information and communication means of distribution of related information resources. There is also a certain list of organizations that support the reliable operation of technologies as the main means of information resources distribution of enterprise [3, 5].

The allocation of computing resources is followed by much greater management decentralization than it could be usually observed in centralized environment, when the data center had strong control over the resources of a large computing system. One of the positive aspects of decentralization is the higher degree of dynamics in multiple areas of computer equipment usage, such as installation and development of applications, connection of peripherals, system expansion, etc.

One of the promising methods to increase the resource management efficiency is implementation of the techniques and tools of new information technology in the performance of the officials. At present the computer, used by authorities as a tool of individual automatization, should be considered as one of the centers of complex technological process of organization document flows of relevant information. The continuity and independence of this technological process requires close attention to the optimization of communication between official's automated workstations, which use local area networks (LANs).

In this work LAN is addressed as a distributed computing system built on the basis of a common data transmission environment (local area network), which provides physical connectivity of all system components, easy system reconfiguration and comprehensive coverage of its structural elements.

The usage of computer networks in organizations allows implementing real-time information links between official structure element, providing efficient and distributed data processing.

Distributed database (DB) is a set of logically interconnected databases, distributed via the computer network [9, 10]. Their creation and maintenance on the basis of LAN allows to automatically implementing optimal, from the standpoint of some particular criteria, filling out of the formalized documents, in the development of which many officials, departments and services are involved.

In general, a Distributed Data Base (DDB) is typically a collection of databases (DBs) that includes fragments of many databases that are located on the different nodes in a computer network and are managed by different management systems (DBMS), still remaining available for sharing in different applications (Fig. 1). A distributed database looks like a regular local database to users and applications. In this sense, the term "distributed" reflects the way the database is organized, but not its external characteristics ("distribution" of the database is invisible from the outside) [9, 10].

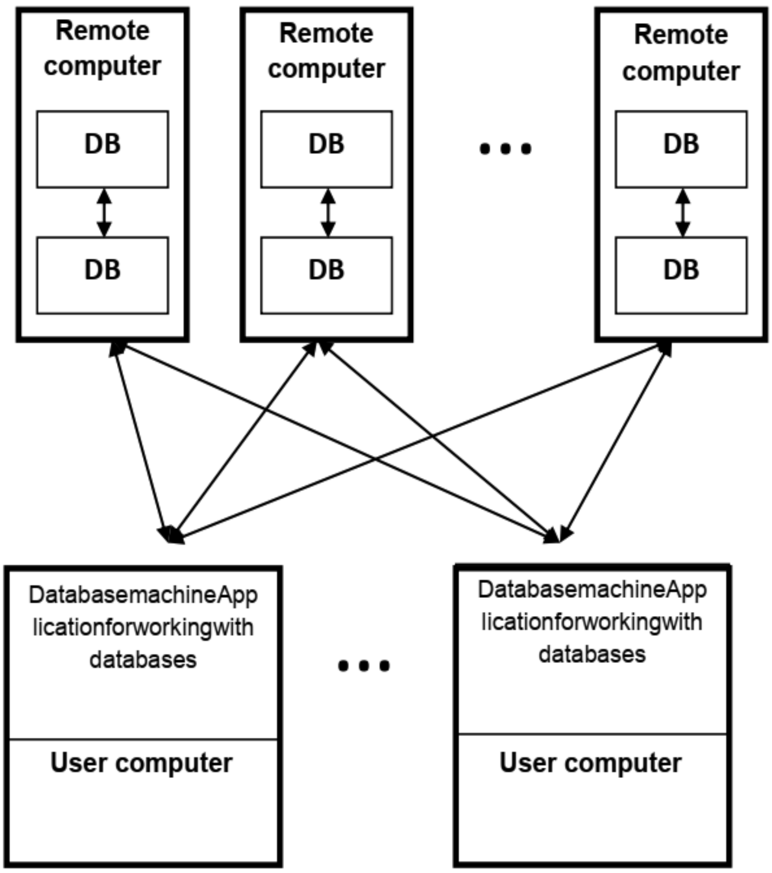

Fig. 1. General view of the distributed database

The usage of computer networks allows implementing information links between elements of the structure of the governing body, including officials, providing prompt and distributed data processing.

Local area networks, having the ability to configure-to-order, allow forming necessary structure of discrete physical elements and processes. This allows fitting into the existing organizational and staffing structure in the early stages of management automatization.

Local area networks are an integral part of distributed in time and space information processing and storage systems. Analysis of foreign literature has shown that local area networks are the main component of information systems during the automatization of managerial work [11, 12]. The main advantage of such networks is the distribution and integration of resources of spatially allocated computers, and at the same time the ability to maintain the information interaction between officials (operators). The optimal distribution of information resources between the workstations is an issue, the solution of which will reduce the time of the decision-making process.

Method

This section presents a method for determining the quasi-optimal distribution of related information resources at designing automated workstations in a local corporate network. Let us directly consider the mathematical allgorithm and method of information resources optimal distribution.

Data set $d_i \in D$, $i = 1, 2, ..., m$, used by N operators, frequency matrix $F = \|f_{ij}\|$ ($i = 1, 2, ..., m, j = 1, 2, ..., N$) of data usage by officials (estimated data flow, unit of measurement - for example, bod). The data should be distributed over sets O_j($j = 1, 2, ..., N$), which form a distributed database of the organization $O = O_1 \cup O_2 \cup ... \cup O_j \cup ... \cup O_N (O_i \cap O_j = \varnothing$ for $i \neq j$).

Each set O_j is located in the base computer of the user (operator) o_j, the computers are connected to the local network of the organization. There is given a matrix of communication values $C = \|c_{kj}\|$ ($k = 1, 2, ..., N; j = 1, 2, ..., N$) of the operator k with the "outlying" database j ($c_{kk} = 0$) –so fee for communication via the network is known.

It is necessary to find a distribution of elements of the set D between sets O_j, which minimizes the total loss from the failed distribution:

$$S = \sum_{k=1}^{N}\sum_{j=1}^{N}\sum_{i=1}^{m} f_{ij} c_{jk} x_{ij} \to \min, \quad (1)$$

Where x_{ij} is the membership function, which is defined as follows:

$$x_{ij} = \begin{cases} 0 \leftrightarrow d_i \in O_j \\ 1 \leftrightarrow d_i \notin O_j \end{cases}, \quad (2)$$

It is clear that in this case $\sum_{j=1}^{N} x_{ij} = 1$.

1. Consider the case when all $c_{ij} = c$ (for $i \neq j$).

The problem has a trivial solution if in the matrix F all elements of a column g are maximal in their rows, so the predicate $\exists g \forall i \forall j \{f_{ig} \geq f_{ij}\ (j \neq g)\}$ is valid. In this case, all elements of the set D must be placed in O_g.

The graph that describes the problem G = (X, U) contains vertices of two types (data $d_1, d_2, ..., d_m \in D$ and operators $o_1, o_2, ..., o_N \in O$), ie $X = D \cup O$, and is dicotyledonous (Fig. 2).

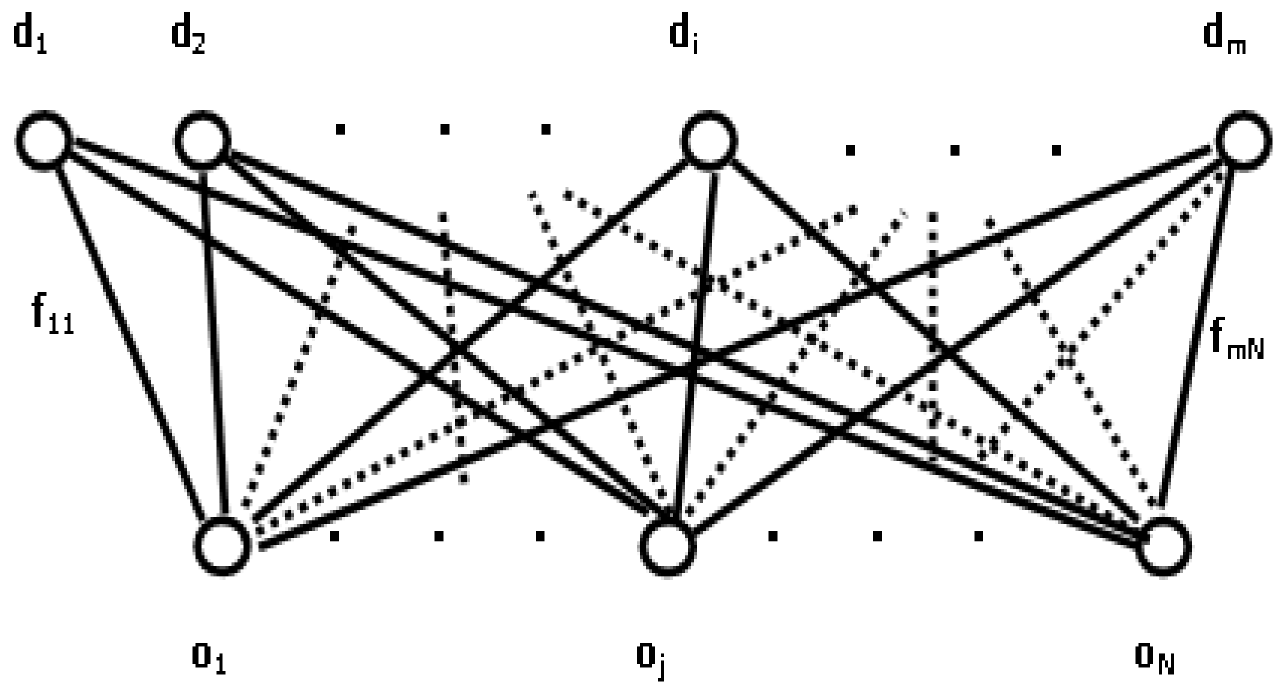

Fig. 2. Graph of the task description

Since the graph is undirected, its description by tuples [10] should be given relatively to the vertices included in the set D:

$$
\begin{array}{l}
<d_1, N, \{<o_1; f_{11}>, <o_2; f_{12}>, ..., <o_i; f_{1i}>, ..., <o_N; f_{1N}>\}> \\
\ldots, \quad \ldots, \quad \ldots, \quad \ldots, \quad \ldots, \quad \ldots, \quad \ldots, \\
\ldots, \quad \ldots, \quad \ldots, \quad \ldots, \quad \ldots, \quad \ldots, \quad \ldots, \\
\ldots, \quad \ldots, \quad \ldots, \quad \ldots, \quad \ldots, \quad \ldots, \quad \ldots, \\
<d_j, N, \{<o_1; f_{j1}>, <o_2; f_{j2}>, ..., <o_i; f_{ji}>, ..., <o_N; f_{jN}>\}>, \\
\ldots, \quad \ldots, \quad \ldots, \quad \ldots, \quad \ldots, \quad \ldots, \quad \ldots \\
\ldots, \quad \ldots, \quad \ldots, \quad \ldots, \quad \ldots, \quad \ldots, \quad \ldots \\
\ldots, \quad \ldots, \quad \ldots, \quad \ldots, \quad \ldots, \quad \ldots, \quad \ldots \\
<d_m, N, \{<o_1; f_{m1}>, <o_2; f_{m2}>, ..., <o_i; f_{mi}>, ..., <o_N; f_{mN}>\}>
\end{array}
\tag{3}
$$

The key idea of the algorithm for the distribution of vertices included in the data set D between N sets, which are formed near the operator vertices o_j, is: the maximum value of f_{ij} for all i and j is determined ($\forall ij(f^*_{i^*j^*} = \max_{ij} f_{ij})$. Data d_{i^*} for which $i=i^*, j=j^*$ ($f_{ij} = f^*_{i^*j^*}$), is attributed to the operator set o_j ($j = j^*$).

The tuple d_i ($i=i^*$) is removed from the description of the graph d_i ($i=i^*$): $D^1 = D \setminus d_{i^*}$. The procedure is repeated until all data is deleted. Since all data must be distributed, the order of processing tuples for d_i does not matter, so for each d_i in its tuple $f^*_{ij^*} = \max_j \Pr_2 \Pr_3 d_j$ is determined and d_i is attributed to the set of operators j^*.

It is better to describe the result in tuples relatively to the vertices included in the set O.

2. General case.

Obviously, when assigning a given d_1 to the set o_1, the partial loss due to such an assignment is $s_{11} = \sum_{j=1}^{N} f_{1j} c_{j1}$. Similarly, for an arbitrary data element d_i its assignment to the set Oj leads to losses:

$$
s_{ij} = \sum_{k=1}^{N} f_{ik} c_{ki} \tag{4}
$$

In the general case, we have a loss matrix $\|s_{ij}\|$ $i = \overline{i, N}, j = \overline{1, N}$.

$$
\|s_{ij}\| = \|f_{ik}\| \times \|c_{kj}\| \tag{5}
$$

The algorithm, which is described above,is focused on using the matrix $\|f_{ij}\|$,and it can be applied to using the matrix $\|s_{ij}\|$. The graph is described by tuples:

$$
\begin{array}{l}
<d_1, N, \{<o_1; s_{11}>, <o_2; s_{12}>, ..., <o_i; s_{1i}>, ..., <o_N; s_{1N}>\}> \\
\ldots, \quad \ldots, \quad \ldots, \quad \ldots, \quad \ldots, \quad \ldots, \quad \ldots, \\
\ldots, \quad \ldots, \quad \ldots, \quad \ldots, \quad \ldots, \quad \ldots, \quad \ldots, \\
\ldots, \quad \ldots, \quad \ldots, \quad \ldots, \quad \ldots, \quad \ldots, \quad \ldots, \\
<d_j, N, \{<o_1; s_{j1}>, <o_2; s_{j2}>, ..., <o_i; s_{ji}>, ..., <o_N; s_{jN}>\}>, \\
\ldots, \quad \ldots, \quad \ldots, \quad \ldots, \quad \ldots, \quad \ldots, \quad \ldots \\
\ldots, \quad \ldots, \quad \ldots, \quad \ldots, \quad \ldots, \quad \ldots, \quad \ldots \\
\ldots, \quad \ldots, \quad \ldots, \quad \ldots, \quad \ldots, \quad \ldots, \quad \ldots \\
<d_m, N, \{<o_1; s_{m1}>, <o_2; s_{m2}>, ..., <o_i; s_{mi}>, ..., <o_N; s_{mN}>\}>
\end{array}
\tag{6}
$$

In contrast to the algorithm of item 1 in this algorithm minimum value of s_{ij} for all i and j is determined ($\forall ij(s^*_{i^*j^*} = \min_{ij} s_{ij})$. Дані d_{i^*}, для яких $i=i^*, j=j^*$ ($s_{ij} = s^*_{i^*j^*}$), are assigned to the set of operator o_j ($j=j^*$).

Next, the algorithm completely coincides with the algorithm described in item 1: the tuple d_i ($i = i^*$) is removed from the graph description: $D^1 = D \setminus d_{i^*}$ The procedure is repeated until all data is removed. For each d_i in its tuple $s^*_{ij^*} = \min_i \Pr_2 \Pr_3 d_j$ is determined and d_i is attributed to the set O_{j^*}. In accordance with the mentioned above a method of quasi-optimal distribution of related resources in the design of workstations in the LAN of the corporation is proposed (Fig. 3).

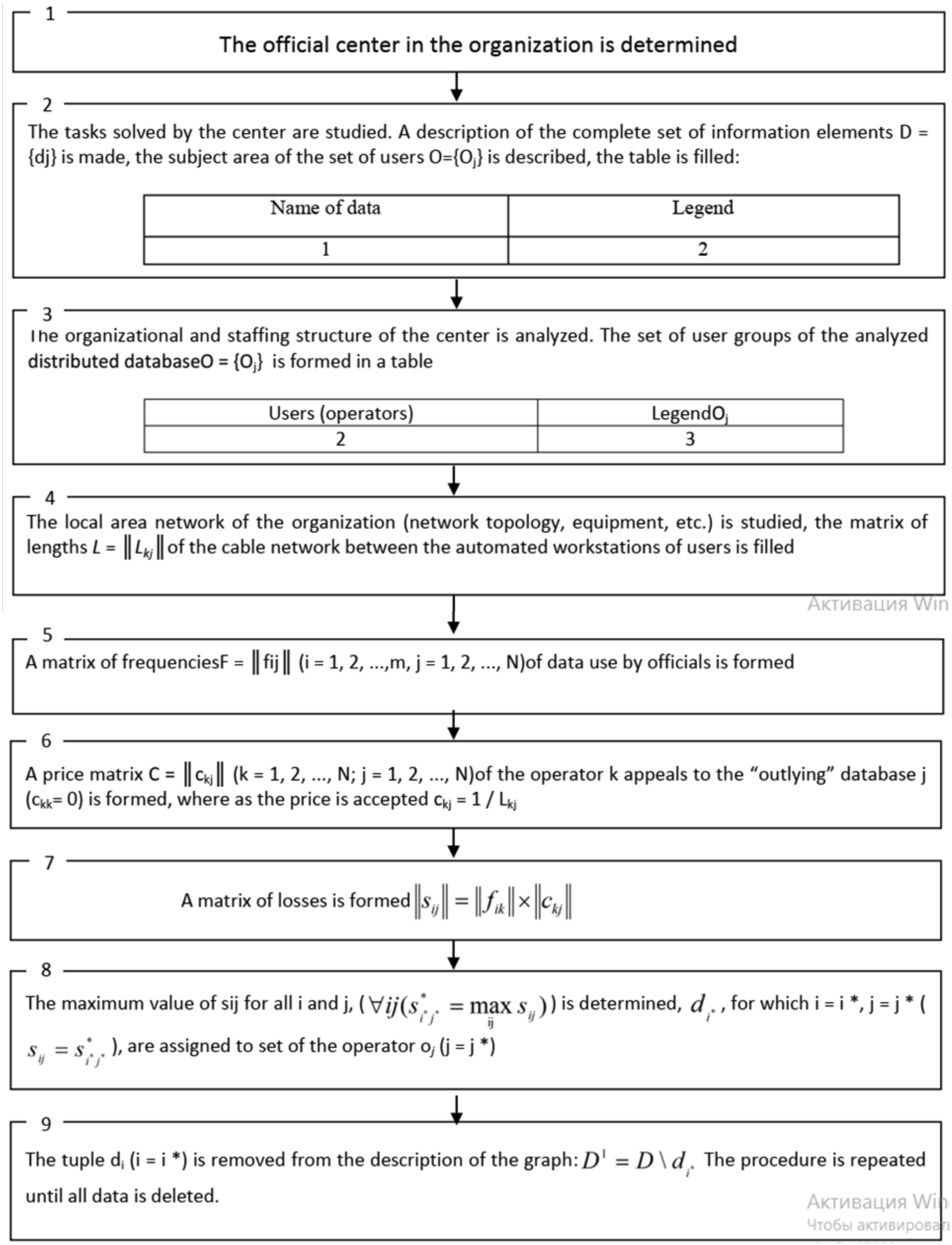

Fig. 3. Method of quasi-optimal distribution of related resources when designing of workstations in the LAN.

Results and discussion

This section presents the results of modeling of optimal distribution of related information resources using the conditional organization as an example.

To explain the algorithm application the example of the simulated organization is considered. Analysis of the organizational and staffing structure of the organization official, the tasks to be solved by departments during the preparation of activities allowed to identify groups of users of the distributed database (Tab. 1).

Table 1. The set of user groups of the considered information system of the organization O = {Oj}

Users (operators)	Legend
Management group	O_1
Group 1	O_2
Group2	O_3
Group3	O_4
Group4	O_5
Group5	O_6
Group6	O_7
Group7	O_8
Group8	O_9
Group9	O_{10}
Group10	O_{11}

Continuous extraction, collection, analysis, generalization and evaluation of situation data under any circumstances aimed at ensuring that the chief makes the justified decision, timely clarification during the work, taking into consideration the changed situation, as well as quality implementation of all other measures to manage the organization.

To manage its activity the organization of any level must have data:

- about competitors;
- expected demand for products;
- the number of products sold for a certain period of time;
- the amount of raw materials from the supplier at the beginning of the working day;
- average daily load;
- the economic condition of the location;
- the social composition of local population;
- the peculiarities of the time of year and day;
- address of supplier or buyer, etc.

Based on the study, five sets of the information elements describing a subject area of users were identified in the information system of the organization:

D1 – a set of information elements (IE), which describes the necessary data about competitors;

D2 – a set of IE, containing the necessary information about organization capabilities;

D3 – a set of IE, that includes the necessary data on the capabilities of competitors;

D4 – set of IE, that describes the geographical required data;

D5 – set of IE, containing the data on the external environment (social-economic, political et cet.)

The set of information elements $D = \{d_j\}$, that describes the subject area of the set of users $O = \{o_j\}$, is obtained by combining the sets *D1, D2, D3, D4, D5*:

$$D1 \cup D2 \cup D3 \cup D4 \cup D5 = D = \{d_j\} \qquad (7)$$

Officials of the organization (groups of operators of the information system) for supplying their work use different IE. The frequency matrix $F = \|f_{ij}\|$ ($i = 1, 2, ...,m, j = 1, 2, ..., N$) of data usage by officials is presented in Table 2, which reproduces the number of appeals to these data per unit time (day).

Table 2. Frequency matrix *F* of data usage by organization officials

		O_1	O_2	O_3	O_4	O_5	O_6	O_7	O_8	O_9	O_{10}	O_{11}
F=	*D*1	175	127	91	20	30	10	107	118	81	62	132
	*D*2	120	123	111	104	90	74	40	75	60	73	10
	*D*3	27	29	19	10	3	2	20	15	19	4	30
	*D*4	56	59	43	6	18	4	27	37	30	12	30
	*D*5	2	11	19	0	2	3	11	20	11	8	18

The matrix of values $C = \|c_{kj}\|$ ($k = 1, 2, ..., N; j = 1, 2, ..., N$) communication of the operator k with the "outlying" database *j* ($c_{kk} = 0$) is given in Table 3:

Table 3. Matrix *C* of values of operator communication

	O_1	O_2	O_3	O_4	O_5	O_6	O_7	O_8	O_9	O_{10}	O_{11}
O_1	0	0,067	0,04	0,013	0,018	0,015	0,013	0,012	0,011	0,015	0,014
O_2	0,067	0	0,025	0,011	0,017	0,013	0,011	0,011	0,011	0,013	0,013
O_3	0,04	0,025	0	0,02	0,067	0,05	0,033	0,026	0,025	0,029	0,017
O_4	0,013	0,011	0,02	0	0,022	0,025	0,04	0,05	0,05	0,018	0,04
O_5	0,018	0,017	0,067	0,022	0	0,029	0,018	0,014	0,014	0,05	0,022
O_6	0,015	0,013	0,05	0,025	0,029	0	0,067	0,029	0,029	0,018	0,013
O_7	0,013	0,011	0,033	0,04	0,018	0,067	0	0,05	0,05	0,013	0,015
O_8	0,012	0,011	0,026	0,05	0,014	0,029	0,05	0	0,333	0,013	0,02
O_9	0,011	0,011	0,025	0,05	0,014	0,029	0,05	0,333	0	0,013	0,022
O_{10}	0,015	0,013	0,029	0,018	0,05	0,018	0,013	0,013	0,013	0	0,04
O_{11}	0,014	0,013	0,017	0,04	0,022	0,013	0,015	0,02	0,022	0,04	0

Here, $c_{kj} = 1/L_{kj}$ is taken as the price, and thereL_{kj} is the length of the cable network between the machines. The task is to distribute data between automated workstations (groups of operators). First of all we solve this problem of distribution, using only the frequency matrix F. According to the algorithm proposed in item 1 we obtain the following distribution:

D1 refers to the database operator O1, because 175 is the maximum for row D1 and is in column O1;
D2 refers to the database of the operator O2;
D3 refers to the database operator O11;
D4 refers to the database of the operator O2;
D5 refers to the database of the operator O8.

In the general case, using the algorithm proposed in item 2, we find the loss matrix $\|s_{ij}\| = \|f_{ik}\| \times \|c_{kj}\|$:

Table 4. Matrix *S* of values of loss

	O_1	O_2	O_3	O_4	O_5	O_6	O_7	O_8	O_9	O_{10}	O_{11}
*D*1	19,64	20,74	25,74	26,9	22,92	25,89	21,6	43,36	55,86	18,39	15,6
*D*2	20,09	17,33	26,71	18,94	22,59	22,09	25,27	37,44	42,32	17,13	18,72
*D*3	4,055	3,505	4,456	4,912	4,236	4,841	4,118	9,72	8,428	3,633	2,772
*D*4	7,87	6,817	8,702	8,529	7,831	8,746	7,641	15,21	17,56	6,412	5,299
*D*5	2,464	1,488	2,335	3,496	3,015	3,18	2,952	5,441	8,458	2,155	1,71

Acting according to the algorithm from item 2, we obtain the following distribution (Tab. 4):

D1 refers to the database operator O11;
D2 refers to the database of the operator O10;
D3 refers to the database operator O11;
D4 refers to the database operator O11;
D5 refers to the database of the O2 operator.

The first and the second results do not match. The structure of the database is significantly influenced by the structure of the network. The use of the proposed method of resource allocation is possible in organizations of any level.

Conclusion

The use of the described algorithm allows to optimally distribute the information resource in the local corporative network, as well as to solve the problem of building a local network with the highest reliability and high efficiency. A method of quasi-optimal distribution of related resources in the design of workstations in local corporative network is proposed. When constructing the optimal structure of a distributed database, many factors that influence the final decision are easily taken into account by including their impact on the cost of communication.

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Information resources distribution between automated workstations
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