Computation Method of Quasi-Optimal Related Resources Distribution Between Automated Workstations in Local Corporative Networks

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Abstract

This investigation focuses on the problem of distribution of information resources between workstations in local networks. The usage of computer networks in corporations allows implementing real-time information links between official structure element, providing efficient and distributed data processing. In this work we present a mathematical description of the algorithm for quasi-optimal distribution of related information resources at designing automated workstations in local corporate network. The undirected graph describing the task of information resources optimal distribution is presented. The computation method of quasi-optimal related resources distribution between automated workstations in local corporative networks has been developed based on presented algorithm. Using conditional corporation as an example the modeling of optimal distribution of related information resources has been considered in local corporative network. Based on the obtained results, five sets of the related information elements describing a subject area were identified in the information system of the conditional corporation: The described computation method 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

1. Introduction

At present, the most peculiarities in corporation's activity are the wide use of IT and the effective distribution of information resources at designing their organizational structures [1, 2]. Modern networking technologies have contributed to revolutionary changes in all spheres of economic activity. New features of computer and information technology affect both the production and sector of service. Networking distributed technologies with high bandwidth is becoming the main channel 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

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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. From the level of distributed network application, directly depends 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 is the basis of economic activity, which depends on the effective of 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 network technologies 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. In modern condition 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. 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.

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.

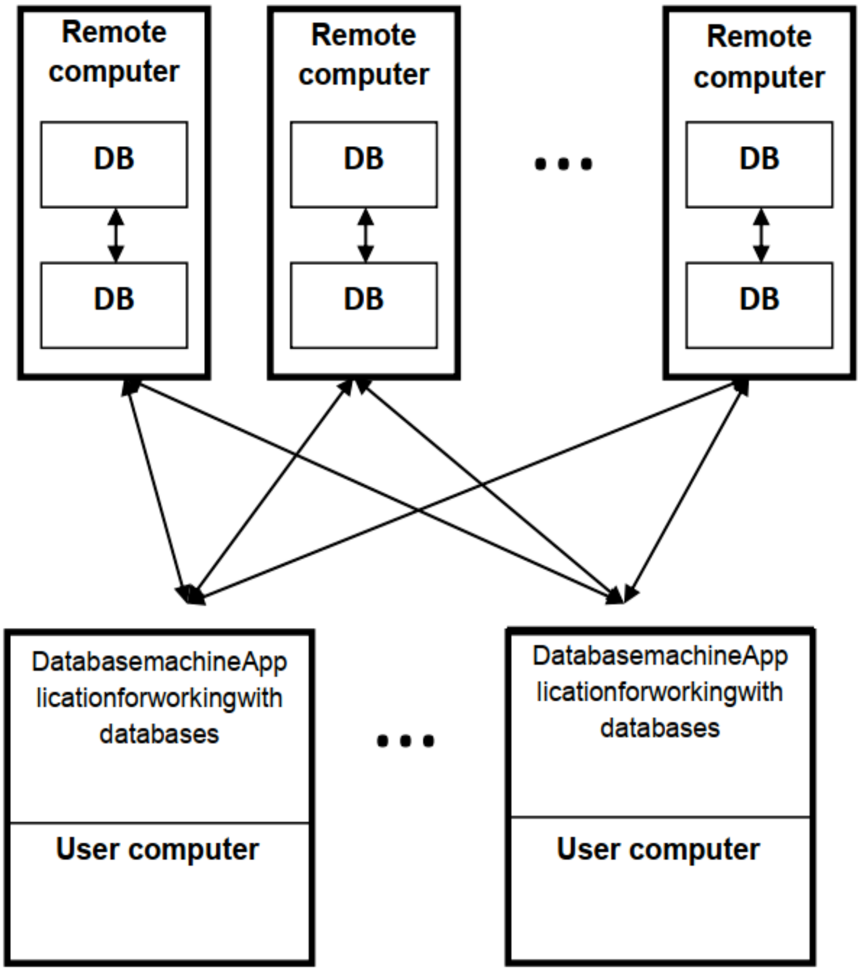

Figure 1: General view of the distributed database

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 (Figure 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].

2. 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 algorithm 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 $O = O_1 \cup O_2 \cup ... \cup O_j \cup ... \cup O_N (O_i \cap O_j = \varnothing \text{for } i \neq j)$.

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:

$$S=\sum_{k=1}^{N}\sum_{j=1}^{N}\sum_{i=1}^{m} f_{ij}c_{jk}x_{ij}\rightarrow \min, \tag{1}$$

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

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

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) [13, 14] contains vertices of two types (data d_1, d_2, ...,$d_m\in D$ and operators o_1, o_2, ..., $o_N\in$ O), i.e. $X=D\cup$ O, and is dicotyledonous (Figure 2).

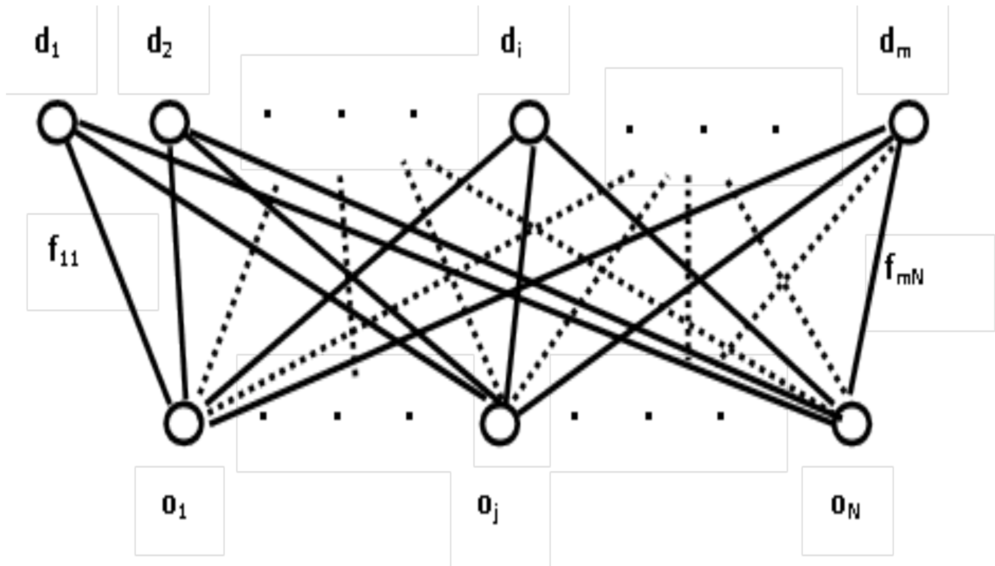

Figure 2: Graph of the task description

Since the graph is undirected, its description by tuples [10, 15] should be given relatively to the vertices included in the set D:

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

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 [16, 17]:

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

In contrast to the others algorithms 1 in this algorithm minimum value of s_{ij} for all i and j is determined ($\forall ij(s^*_{i^*j^*} = \min_{ij} s_{ij})$). Data d_{i^*}, for which $i=i^*$, $j=j^*$ ($s_{ij} = s^*_{i^*j^*}$),are attributed to the set of the 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 $s^*_{ij^*} = \min_j \Pr_2 \Pr_3 d_j$ 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 (Figure 3).

1

The official center in the organization is determined

2

The tasks solved by the center are studied. A description of the complete set of information elements D = {dj} is made, the subject area of the set of users O={O_j} is described, the table is filled:

Name of data	Legend
1	2

3

The organizational and staffing structure of the center is analyzed. The set of user groups of the analyzed distributed databaseO = {O_j} is formed in a table

Users (operators)	LegendO_j
2	3

4

The local area network of the organization (network topology, equipment, etc.) is studied, the matrix of lengths $L = \|L_{kj}\|$ of the cable network between the automated workstations of users is filled

5

A matrix of frequenciesF = ‖fij‖ (i = 1, 2, ...,m, j = 1, 2, ..., N)of data use by officials is formed

6

A price matrix C = $\|c_{kj}\|$ (k = 1, 2, ..., N; j = 1, 2, ..., N)of the operator k appeals to the "outlying" database j (c_{kk}= 0) is formed, where as the price is accepted c_{kj} = 1 / L_{kj}

7

A matrix of losses is formed $\|s_{ij}\| = \|f_{ik}\| \times \|c_{kj}\|$

8

The maximum value of sij for all i and j, ($\forall ij(s^*_{i^*j^*} = \max_{ij} s_{ij})$) is determined, d_{i^*}, for which i = i *, j = j * ($s_{ij} = s^*_{i^*j^*}$), are assigned to set of the operator o_j (j = j *)

9

The tuple d_i (i = i *) is removed from the description of the graph: $D^1 = D \setminus d_{i^*}$ The procedure is repeated until all data is deleted.

Figure 3: Method of quasi-optimal distribution of related resources when designing of workstations in the LAN

3. Results and discussion

In this section presented the results of modeling of optimal distribution of related information resources using the conditional organization as an example. To explain the algorithm, its work on 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 identifying groups of users of the distributed database (Table 1).

Table 1
The set of user groups of the considered information system of the organization $O = \{O_j\}$

Users (operators)	Legend
Management group	O_1
Group 1	O_2
Group 2	O_3
Group 3	O_4
Group 4	O_5
Group 5	O_6
Group 6	O_7
Group 7	O_8
Group 8	O_9
Group 9	O_{10}
Group 10	O_{11}
Group 11	O_{12}

Continuous extraction, collection, analysis, generalization and evaluation of situation data in any circumstances aim to ensure 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 district;
- the social and class 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*:

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

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}	O_{12}
	D1	132	127	175	40	118	81	91	102	35	62	80	62
	D2	111	123	10	75	120	60	104	74	55	73	90	90
F=	*D3*	29	20	3	5	30	19	2	2	1	4	10	27
	D4	59	56	18	12	6	30	31	43	5	37	36	25
	D5	2	19	2	18	0	3	11	11	7	8	20	11

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_{12}
	O_1	0,000	0,067	0,04	0,043	0,05	0,048	0,020	0,200	0,04	0,043	0,037	0,056
	O_2	0,067	0,000	0,036	0,031	0,029	0,028	0,026	0,027	0,048	0,026	0,038	0,026
	O_3	0,040	0,036	0,000	0,100	0,067	0,050	0,048	0,059	0,025	0,029	0,029	0,038
	O_4	0,043	0,031	0,100	0,000	0,111	0,071	0,067	0,083	0,033	0,043	0,040	0,067
	O_5	0,050	0,029	0,067	0,111	0,000	0,143	0,077	0,1	0,042	0,05	0,043	0,071
C=	O_6	0,048	0,028	0,05	0,071	0,143	0,000	0,067	0,125	0,050	0,045	0,042	0,059
	O_7	0,02	0,026	0,048	0,067	0,077	0,067	0,000	0,125	0,056	0,125	0,100	0,167
	O_8	0,200	0,027	0,059	0,083	0,100	0,125	0,125	0,000	0,040	0,063	0,048	0,067
	O_9	0,040	0,048	0,025	0,033	0,042	0,050	0,056	0,040	0,000	0,083	0,111	0,077
	O_{10}	0,043	0,026	0,029	0,043	0,050	0,045	0,125	0,063	0,083	0,000	0,167	0,111
	O_{11}	0,037	0,038	0,029	0,040	0,043	0,042	0,100	0,048	0,111	0,167	0,000	0,071
	O_{12}	0,056	0,026	0,038	0,067	0,071	0,059	0,167	0,067	0,077	0,111	0,071	0,000

Here, $c_{kj} = 1/L_{kj}$ is taken as the price, and there L_{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 proposed algorithm we obtain the following distribution (Figure 4):

- $D1$ refers to the database operator O_3, because 175 is the maximum for row $D1$ and is in column O_3;
- $D2$ refers to the database of the operator O_2;
- $D3$ refers to the database operator O_2;
- $D4$ refers to the database of the operator O_1;
- $D5$ refers to the database of the operator O_{11}.

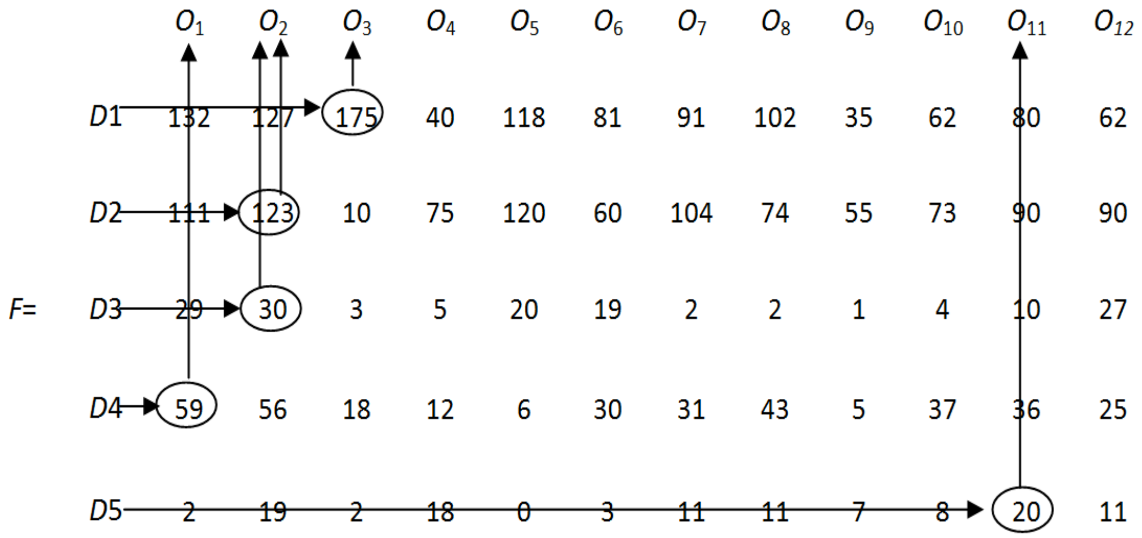

Figure 4: Graphical choice explanation

In the general case, using the proposed algorithm, we find the loss matrix $\|s_{ij}\| = \|f_{ik}\| \times \|c_{kj}\|$.(Table 4).

Table 4
Matrix S of loss values

		O_1	O_2	O_3	O_4	O_5	O_6	O_7	O_8	O_9	O_{10}	O_{11}	O_{12}
S=	D1	59,69	35,18	43,38	71,87	67,68	68,64	72,24	89,98	53,96	66,29	57,49	70,53
	D2	51,31	30,4	46,13	55	58,42	63	69,59	81,91	52,79	67,55	58,48	67,93
	D3	6,6	4,962	7,001	9,584	8,467	9,349	11,46	15,12	8,267	9,579	7,227	7,549
	D4	20,45	11,19	14,64	19,46	23,51	19,32	24,82	29,49	20,08	22,5	20,5	23,54
	D5	6,672	3,04	5,278	4,859	7,514	6,311	8,632	6,747	6,571	8,764	6,228	7,487

Acting according to the algorithm, we obtain the following distribution (Table 4):

- D1 refers to the database operator O_8;
- $D2$ refers to the database operator O_8;
- $D3$ refers to the database operator O_8;
- $D4$ refers to the database operator O_8;
- $D5$ refers to the database operator O_{10}.

The first and fifth 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 related resources distribution is possible in organizations of any level.

4. Conclusions

Based on the analysis of management concepts of information systems and effectiveness of the LAM functioning, criteria are determined that can be used as a basis of the model for solving the tasks of optimal related resources distribution in information systems. 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 in the cost of communication between resources.

5. Acknowledgements

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