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CONSTRUCTION OF A MATHEMATICAL MODEL FOR FINDING A DANCE STUDIO IN THE FORM OF A LOGICAL NETWORK USING FINITE PREDICATE ALGEBRA

The article is devoted to the research and implementation of methods and tools of finite predicate algebra for conducting a systematic analysis of the subject area, exemplified by the formalization of the task of finding a dance studio based on selected parameters. Specifically, the process of choosing a studio depends on a number of parameters: the type of subscription based on the number of sessions, groups, specific dance style, the professionalism of the instructor, the location and proximity to certain types of transport, and the price. The goal of the work is to increase the processing speed of knowledge in the task of finding the optimal subscription by decomposing the initial multi-parameter relationship into a composition of binary ones. The methodology is based on the tools and methods of finite predicate algebra. The application of predicate decomposition in the method of constructing logical networks ensures parallel knowledge processing, thereby increasing query processing speed, while formalization through finite predicates provides universality in describing any subject area. Thus, the complex multi-parameter relationship was decomposed into a composition of binary relations, described in the language of predicate algebra, considering a detailed analysis of the subject area and further decompositions. The scientific novelty lies in the constructed mathematical model of the task of finding a dance studio, represented as a predicate depending on ten variables. This predicate is characterized by the composition of thirteen binary predicates, which are presented in the article as bipartite graphs and formulas of the corresponding predicates. The predicate of the model is a composition of all the constructed binary predicates. The practical significance is determined by the logical network built on the basis of the mathematical model, which allows transitioning from a "many-to-many" relationship to "one-to-one" relationships and parallelizing the information processing. The result of the work is the constructed logical network for the task of finding the optimal dance studio subscription based on specific input parameters, which facilitates the solution of synthesis, analysis, and comparison tasks.

Keywords: finite predicate algebra, decomposition, logical network, mathematical model, binary relation, dance studio, subject area.

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ПОБУДОВА МАТЕМАТИЧНОЇ МОДЕЛІ ПОШУКУ ТАНЦЮВАЛЬНОЇ СТУДІЇ У ВИГЛЯДІ ЛОГІЧНОЇ МЕРЕЖІ ЗАСОБАМИ АЛГЕБРИ СКІНЧЕННИХ ПРЕДИКАТІВ

Статтю присвячено дослідженню та впровадженню методів та засобів алгебри скінченних предикатів для проведення системного аналізу предметної області на прикладі формалізації задачі пошуку танцювальної студії за обраними параметрами. Зокрема, процес вибору студії залежить від ряду наступних параметрів: вид абонементу в залежності від кількості занять, груп, конкретного танцювального напрямку, від професійності викладача, місця розташування та віддаленості від певного виду транспорта, від ціни. Метою роботи є підвищення швидкодії обробки знань в задачі пошуку оптимального абонементу за рахунок розбиття вхідного багатомісцевого відношення на композицію бінарних. Методика грунтується на засобах та методах алгебри скінченних предикатів. Застосування декомпозиції предикатів у методі побудови логічних мереж забезпечує паралельну обробку знань і цим дозволяє підвищити швидкість обробки запиту, а формалізація засобами скінченних предикатів дає універсальність опису будь-якої предметній області.

Таким чином, складне багатомісцеве відношення було розбито на композицію бінарних відношень, що описуються мовою алгебри предикатів з урахуванням деталізованого аналізу предметної області та подальших декомпозицій. Науковою новизною являється побудована математична модель задачі пошуку танцювальної студії, яку подано предикатом, що залежить від десяти змінних. Цей предикат характеризується композицією тринадцяти бінарних предикатів, які в статті представлено дводольними графами та формулами відповідних предикатів. Предикат моделі є композицією усіх побудованих бінарних предикатів. Практична значимість обумовлюється побудованою на основі математичної моделі логічною мережею, що дозволяє від відношення «багато до багатьох» перейти до відношень «один до одного» та розпаралелити процес обробки інформації. Результатом роботи є побудована логічна мережа задачі пошуку оптимального абонементу танцювальної студії за певними вхідними параметрами та дозволяє розв'язувати задачі синтезу, аналізу та порівняння.

Ключові слова: алгебра скінченних предикатів, декомпозиція, логічна мережа, математична модель, бінарне відношення, танцювальна студія, предметна область.

Introduction

The continuous accumulation of information and its increasing volume lead users to turn to search engines more frequently. An important issue is finding approaches to processing knowledge of various natures and large volumes of data [1]. The more diverse the forms of data presentation, the more types of search systems are developed. Sometimes, problems that arise when searching large volumes of data are addressed using technical tools. However, there are often certain limitations in these cases, and sometimes, depending on the subject area, significant errors may occur. An important task today is to find a mathematical framework and corresponding methods that would allow for the construction of a mathematical model of a search system. To develop an intelligent search system, it is necessary to analyze and be able to process knowledge [2].

Related works

Currently, the application of finite predicate algebra as a mathematical framework of a high level of abstraction, which allows for the formalization of knowledge of any nature (text, numerical data), has been considered [3-5]. The article proposes an approach to constructing a model for finding a dance studio in the form of a logical network [6-10]. The method for constructing a logical network is based on the use of predicate algebra tools and allows for the model to be constructed in such a way that the dimensionality of the original multi-parameter relationship is reduced, and the corresponding partitions are divided into groups of nodes that can operate in parallel [11]. In addition, in the nodes, not specific data but domain-specific knowledge is processed, which is characteristic of intelligent systems [12].

The task is to construct an intelligent system that automates the process of finding a dance studio that meets specific requirements (criteria).

Construction of a mathematical model for finding a dance studio in the form of a logical network using finite predicate algebra

Various factors influence the choice of a studio, such as location, price, the level of the instructor, or the number of classes included in the subscription. Certain categories of criteria are interrelated, while others are independent of each other. Therefore, a crucial initial task is to create a paradigmatic table that lists the maximum number of attributes that allows the selection of a studio. Subsequently, it is necessary to identify the internal relationships between the criteria, which will help to delineate subgroups of relevant criteria, as well as the relationships between these subgroups [13].

The following attributes are distinguished: studio name, type of subscription based on the number of classes, subscription price, presence of a studio branch, instructor level, type of subscription by age, and distance to the nearest metro station. An intelligent system in the form of a logical network was constructed for finding dance studios in Kyiv.

The construction of the logical network is based on the concepts of finite predicate algebra, where a predicate serves as a function that defines a one-to-one correspondence between a multi-parameter relationship and the logical variables 0 and 1. Therefore, an important stage in the construction is the analysis of the subject area by identifying essential subject variables and their features, recording the corresponding multi-parameter relationships, and the connections between them. A challenging aspect of this analysis is the identification of groups of features from the set of essential attributes that are semantically similar, which means they reflect related relationships.

We examine the dependence of the subscription price on the studio, the number of classes, the instructor's level, age, and the branch's district. A paradigmatic table will be constructed to present the main data influencing the choice of the studio.

Table 1

A paradigmatic table of the dependence of the studio name, cost, and number of classes in the subscription

Studio name	**Subscription type**			
	1	**4**	**8**	**12**
Dside	300	1180	1870	2700
	350	1350	1970	2850
	400	1500	2070	2990
MyWay	170	1140	995	
	240	540	1425	
			1815	
	345	865	970	
			1360	
Mix Style	150	560	960	1320
Dream Team	250		1500	2160
			1200	1800
All Stars	250		1390	
Open Art	200	750	1350	1650
		720	1280	1490
FREEWAY	150	580	900	1150
ДІМ	300	1000	1300	
	350	1300	1750	
	400	1400	2100	

The table shows that the studio name and the type of subscription do not uniquely determine the cost. There are other factors affecting the price: the instructor's level, the type of subscription by age, and the type of subscription by district. Accordingly, each of these factors has its own domain of definition. For example, the price of "240 UAH" is defined for the studio "MyWay" for one class with a basic-level instructor; while the price of "1425 UAH" is the cost for 8 classes at the same studio, with the same basic-level instructor, but for children (the price for an adult group would be different). The price of "750 UAH" at the studio "Open Art" is for a subscription of 4 classes in the Poznyaky area, indicating that another influencing factor is the location of the branch.

Next, for constructing the mathematical model of the given problem, it is necessary to introduce subject variables, each corresponding to the following values:

x_1 – studio (*DS* – «Dside», *MW* – «MyWay», *MS* – «Mix Style», *DT* – «Dream Team», *AS* – «AllStars», *OA* – «Open Art», *FW* – «FreeWay», *D* – «Dim»);

x_2 – type of subscription by the number of classes (1, 4, 8, 12);
x_3 – type of subscription by the instructor's level (*S* – «Start», *B* – «Base», *T* – «Top»);
x_4 – type of subscription by age («children's» - *K* or «adult» - *A*);
x_5 – type of subscription by location of a branch («Pozniaky» - *P*, «Borshchahivka» - *B*). The cells of the paradigmatic table will be numbered.

Table 2

Paradigmatic table

Studio	**Subscription type**			
	1	**4**	**8**	**12**
Dside	1	4	7	10
	2	5	8	11
	3	6	9	12
MyWay	13	16	19	
	14	17	20	
			21	
	15	18	22	
			23	
Mix Style	24	25	26	27
Dream Team	28		29	31
			30	32
All Stars	33		34	
Open Art	35	36	38	40
		37	39	41
FREEWAY	42	43	44	45
DIM	46	49	52	
	47	50	53	
	48	51	54	

For further construction, it is necessary to express the numbers q of the cells in the paradigmatic table through the above-mentioned features x_1-x_5:

$x_1^{DS}x_2^1x_3^S = q^1$; $x_1^{DS}x_2^1x_3^B = q^2$; $x_1^{DS}x_2^1x_3^T = q^3$; $x_1^{DS}x_2^4x_3^S = q^4$; $x_1^{DS}x_2^4x_3^B = q^5$; $x_1^{DS}x_2^4x_3^T = q^6$; $x_1^{DS}x_2^8x_3^S = q^7$; $x_1^{DS}x_2^8x_3^B = q^8$; $x_1^{DS}x_2^8x_3^T = q^9$; $x_1^{DS}x_2^{12}x_3^S = q^{10}$; $x_1^{DS}x_2^{12}x_3^B = q^{11}$; $x_1^{DS}x_2^{12}x_3^T = q^{12}$; $x_1^{MW}x_2^1x_3^Sx_4^A = q^{13}$; $x_1^{MW}x_2^1x_3^Bx_4^A = q^{14}$; $x_1^{MW}x_2^1x_3^Tx_4^A = q^{15}$; $x_1^{MW}x_2^4x_3^Tx_4^A = q^{16}$; $x_1^{MW}x_2^4x_3^Sx_4^K = q^{17}$; $x_1^{MW}x_2^4x_3^Tx_4^K = q^{18}$; $x_1^{MW}x_2^8x_3^Sx_4^A = q^{19}$; $x_1^{MW}x_2^8x_3^Bx_4^A = q^{20}$; $x_1^{MW}x_2^8x_3^Tx_4^A = q^{21}$; $x_1^{MW}x_2^8x_3^Sx_4^K = q^{22}$; $x_1^{MW}x_2^8x_3^Tx_4^K = q^{23}$; $x_1^{MS}x_2^1 = q^{24}$; $x_1^{MS}x_2^4 = q^{25}$; $x_1^{MS}x_2^8 = q^{26}$; $x_1^{MS}x_2^{12} = q^{27}$; $x_1^{DT}x_2^1 = q^{28}$; $x_1^{DT}x_2^8x_4^A = q^{29}$; $x_1^{DT}x_2^8x_4^K = q^{30}$; $x_1^{DT}x_2^{12}x_4^A = q^{31}$; $x_1^{DT}x_2^{12}x_4^K = q^{32}$; $x_1^{AS}x_2^1 = q^{33}$; $x_1^{AS}x_2^8 = q^{34}$; $x_1^{OA}x_2^1 = q^{35}$; $x_1^{OA}x_2^4x_5^P = q^{36}$; $x_1^{OA}x_2^4x_5^B = q^{37}$; $x_1^{OA}x_2^8x_5^P = q^{38}$; $x_1^{OA}x_2^8x_5^B = q^{39}$; $x_1^{OA}x_2^{12}x_5^P = q^{40}$; $x_1^{OA}x_2^{12}x_5^B = q^{41}$; $x_1^{FW}x_2^1 = q^{42}$; $x_1^{FW}x_2^4 = q^{43}$; $x_1^{FW}x_2^8 = q^{44}$; $x_1^{FW}x_2^{12} = q^{45}$; $x_1^{D}x_2^1x_3^S = q^{46}$; ; $x_1^{D}x_2^1x_3^B = q^{47}$; $x_1^{D}x_2^1x_3^T = q^{48}$; $x_1^{D}x_2^4x_3^S = q^{49}$; $x_1^{D}x_2^4x_3^B = q^{50}$; $x_1^{D}x_2^4x_3^T = q^{51}$; $x_1^{D}x_2^8x_3^S = q^{52}$; $x_1^{D}x_2^8x_3^B = q^{53}$; $x_1^{D}x_2^8x_3^T = q^{54}$.

The element-wise disjunction operation will be performed on as many related equalities as possible, and the dependence of the influence number r of the considered group of features that determine the subscription price will be formed based on the cell numbers q of the paradigmatic table:

$$x_1^{DS}x_3^{S}(x_2^1 \vee x_2^4 \vee x_2^8 \vee x_2^{12}) = q^1 \vee q^4 \vee q^7 \vee q^{10} = r^1,$$
$$x_1^{DS}x_3^{B}(x_2^1 \vee x_2^4 \vee x_2^8 \vee x_2^{12}) = q^2 \vee q^5 \vee q^8 \vee q^{11} = r^2,$$
$$x_1^{DS}x_3^{T}(x_2^1 \vee x_2^4 \vee x_2^8 \vee x_2^{12}) = q^3 \vee q^6 \vee q^9 \vee q^{12} = r^3,$$
$$x_1^{MW}x_2^1x_4^A(x_3^S \vee x_3^B \vee x_3^T) = q^{13} \vee q^{14} \vee q^{15} = r^4,$$
$$x_1^{MW}x_2^4x_3^Tx_4^A = q^{16} = r^5,$$
$$x_1^{MW}x_2^4x_4^K(x_3^S \vee x_3^T) = q^{17} \vee q^{18} = r^6,$$
$$x_1^{MW}x_2^8x_4^A(x_3^S \vee x_3^B \vee x_3^T) = q^{19} \vee q^{20} \vee q^{21} = r^7,$$
$$x_1^{MW}x_2^8x_4^K(x_3^S \vee x_3^T) = q^{17} \vee q^{18} = r^8,$$
$$x_1^{MS}(x_2^4 \vee x_2^8 \vee x_2^{12}) = q^{25} \vee q^{26} \vee q^{27} = r^9,$$
$$x_1^{DT}x_2^8(x_4^A \vee x_4^K) = q^{29} \vee q^{30} = r^{10},$$
$$x_1^{DT}x_2^{12}(x_4^A \vee x_4^K) = q^{31} \vee q^{32} = r^{11},$$
$$x_1^{AS}x_2^8 = q^{34} = r^{12},$$
$$x_1^{OA}x_5^P(x_2^4 \vee x_2^8 \vee x_2^{12}) = q^{36} \vee q^{38} \vee q^{40} = r^{13},$$
$$x_1^{OA}(x_2^4 \vee x_2^8 \vee x_2^{12})x_5^B = q^{37} \vee q^{39} \vee q^{41} = r^{14},$$
$$x_1^{FW}(x_2^4 \vee x_2^8 \vee x_2^{12}) = q^{43} \vee q^{44} \vee q^{45} = r^{15},$$
$$(x_1^{MS} \vee x_1^{DT} \vee x_1^{AS} \vee x_1^{OA} \vee x_1^{FW})\, x_2^1 = q^{24} \vee q^{28} \vee q^{33} \vee q^{35} \vee q^{42} = r^{16},$$
$$x_1^{D}x_2^1(x_3^S \vee x_3^B \vee x_3^T) = q^{46} \vee q^{47} \vee q^{48} = r^{17},$$
$$x_1^{D}x_2^4(x_3^S \vee x_3^B \vee x_3^T) = q^{49} \vee q^{50} \vee q^{51} = r^{18},$$
$$x_1^{D}x_2^8(x_3^S \vee x_3^B \vee x_3^T) = q^{52} \vee q^{53} \vee q^{54} = r^{19}.$$

The established dependencies of the influence number r on the variables x_1, x_2, x_3, x_4, x_5 enable the binarization of the relations connecting the variable r with the variables x_1, x_2, x_3, x_4, x_5 (1)-(5). The obtained relations will be represented as bipartite graphs (Fig. 1-5.).

$$P_1(x_1, r) = x_1^{DS}(r^1 \vee r^2 \vee r^3) \vee x_1^{MW}(r^4 \vee r^5 \vee r^6 \vee r^7 \vee r^8) \vee x_1^{MS}r^9 \vee x_1^{DT}(r^{10} \vee r^{11}) \vee x_1^{AS}r^{12} \vee x_1^{OA}(r^{13} \vee r^{14}) \vee x_1^{FW}r^{15} \vee (x_1^{MS} \vee x_1^{DT} \vee x_1^{AS} \vee x_1^{OA} \vee x_1^{FW})r^{16} \vee x_1^{D}(r^{17} \vee r^{18} \vee r^{19}) \quad (1)$$

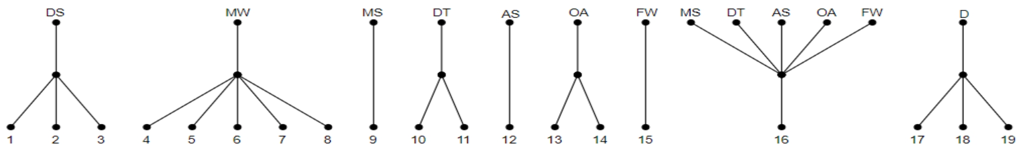

Fig.1. Graph of the relationship between r and x_1 variables

Similarly, the binarization of the relation with respect to the variables x_2, r (2) is performed and represented as graphs (Fig. 2):

$$P_2(x_2, r) = (x_2^1 \vee x_2^4 \vee x_2^8 \vee x_2^{12})(r^1 \vee r^2 \vee r^3) \vee x_2^1(r^4 \vee r^{16} \vee r^{17}) \vee x_2^4(r^5 \vee r^6 \vee r^{18}) \vee x_2^8(r^7 \vee r^8 \vee r^{10} \vee r^{12} \vee r^{19}) \vee (x_2^4 \vee x_2^8 \vee x_2^{12})(r^9 \vee r^{13} \vee r^{14} \vee r^{15}) \vee x_2^{12}r^{11}. \quad (2)$$

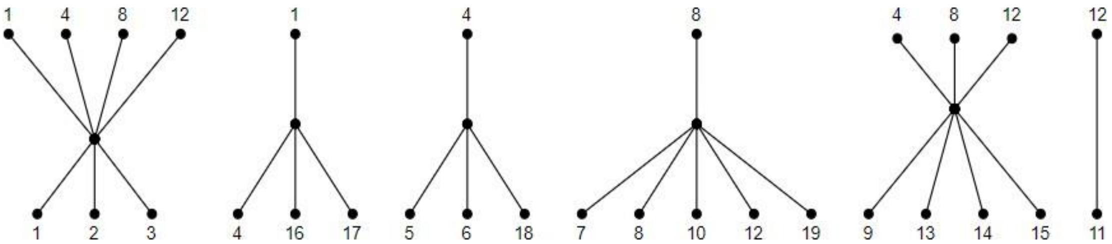

Fig.2. Graph of the relationship between r and x_2 variables

The relation $P_3(x_3, r)$ (3), which connects the variables x_3 and r, is identified and represented as the corresponding graphs (Fig. 3):

$$P_3(x_3, r) = x_3^S r^1 \lor x_3^B r^2 \lor x_3^T (r^3 \lor r^5) \lor (x_3^S \lor x_3^T)(r^6 \lor r^8) \lor$$
$$\lor (x_3^S \lor x_3^B \lor x_3^T)(r^4 \lor r^7 \lor r^9 \lor r^{10} \lor r^{11} \lor r^{12} \lor r^{13} \lor r^{14} \lor r^{15} \lor r^{16} \lor r^{17} \lor r^{18} \lor r^{19}). \quad (3)$$

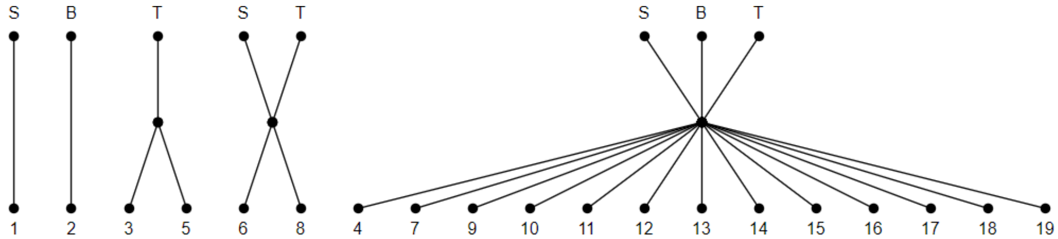

Fig.3. Graph of the relationship between r and $x3$ variables

The relation $P_4(x_4, r)$ (4), which connects the variables x_4 and r, is identified and represented as the corresponding graphs (Fig.4):

$$P_4(x_4, r) = x_4^A (r^4 \lor r^5 \lor r^7 \lor r^{17} \lor r^{18} \lor r^{19}) \lor x_4^K (r^6 \lor r^8) \lor (x_4^A \lor x_4^K)(r^1 \lor r^2 \lor r^3 \lor r^9 \lor r^{10} \lor r^{11} \lor$$
$$\lor r^{12} \lor r^{13} \lor r^{14} \lor r^{15} \lor r^{16}). \quad (4)$$

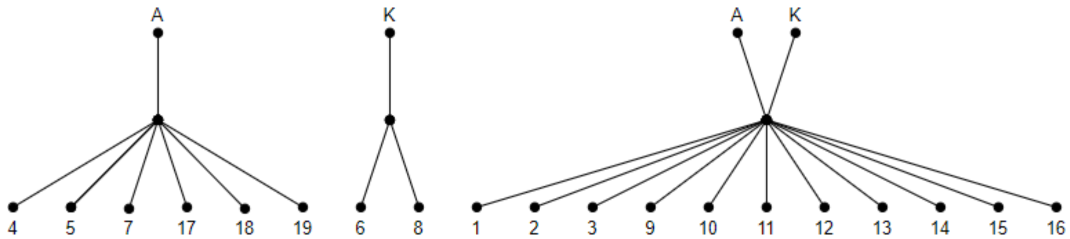

Fig.4. Graph of the relationship between r and $x4$ variables

The relation $P5(x5, r)$ (5), which connects the variables $x5$ and r, is identified and represented as the corresponding graphs (Fig.5):

$$P_5(x_5, r) = x_5^P r^{13} \lor x_5^B r^{14}. \quad (5)$$

Fig.5. Graph of the relationship between r and $x5$ variables

The location of the studio also plays a significant role in its selection. Therefore, an analysis of the availability of branches and the distance from the studio to the nearest metro and bus stops must be conducted. The distance from the studio to the nearest stop will be denoted by the variable x6x_6x6, with corresponding values representing time intervals in minutes. This information will be added to Table 3.

Table 3

Studio	Branch	Time to the nearest stop, $x6$	
		metro	**bus**
Dside	Livyi bereh	15 minutes	2 minutes
	Pravyi bereh	7 minutes	3 minutes
MyWay		15 minutes	5 minutes
Mix Style	Holosiievo	16 minutes	3 minutes
	Troieshchyna	80 minutes	3 minutes
Dream Team		5 minutes	2 minutes
All Stars		5 minutes	5 minutes
Open Art	Pozniaky	7 minutes	9 minutes
	Borshchahivka	62 minutes	3 minutes
Free Way		15 minutes	5 minutes
Dim		14 minutes	2 minutes

Next, it should be noted that x_1 represents the studio name (DS – «Dside», MW – «MyWay», MS – «Mix Style», DT – «Dream Team», AS – «AllStars», OA – «Open Art», FW – «FreeWay», D – «Дім»), x_5 refers to the branch location (LB – «Livyi bereh», PB – «Pravyi bereh», G – «Holosiievo», T – «Troieshchyna», P – «Pozniaky», B – «Borshchahivka»). Additionally, variable x_6 is introduced with the values M – «metro station», A – «bus stop».

$x_1^{DS}x_5^{LB} = q_1$; $x_1^{DS}x_5^{PB} = q_2$; $x_1^{MW} = q_3$; $x_1^{MS}x_5^{G} = q_4$; $x_1^{MS}x_5^{T} = q_5$; $x_1^{DT} = q_6$; $x_1^{AS} = q_7$; $x_1^{OA}x_5^{P} = q_8$; $x_1^{OA}x_5^{B} = q_9$; $x_1^{FW} = q_{10}$; $x_1^{D} = q_{11}$.

Disjunctions will be combined where possible:

$$x_1^{DS}(x_5^{LB} \vee x_5^{PB}) = q_1 \vee q_2 = z^1;$$
$$x_1^{MW} = q_3 = z^2;$$
$$x_1^{MS}(x_5^{G} \vee x_5^{T}) = q_4 \vee q_5 = z^3;$$
$$x_1^{DT} = q_6 = z^4;$$
$$x_1^{AS} = q_7 = z^5;$$
$$x_1^{OA}(x_5^{P} \vee x_5^{B}) = q_8 \vee q_9 = z^6;$$
$$x_1^{FW} = q_{10} = z^7;$$
$$x_1^{D} = q_{11} = z^8.$$

Thus, the following disjunctive-conjunctive normal form is obtained:

$$P_6(x_1, z) = x_1^{DS}z^1 \vee x_1^{MW}z^2 \vee x_1^{MS}z^3 \vee x_1^{DT}z^4 \vee x_1^{AS}z^5 \vee x_1^{OA}z^6 \vee x_1^{FW}z^7 \vee x_1^{D}z^8.$$

In graphical form, our function is presented in Fig.6.

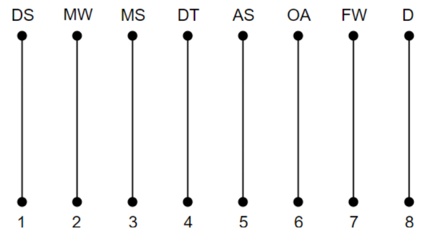

Fig.6. Graph of the relationship between z and $x1$ variables

Next, it is necessary to examine the dependence of the branch (based on the studio's location) on the auxiliary variable z, which will allow the relationship with the studio's name to be presented in a more compact form:

$$P_7(x_5, z) = (x_5^{LB} \vee x_5^{PB})z^1 \vee (x_5^{G} \vee x_5^{T})\, z^3 \vee (x_5^{P} \vee x_5^{B})z^6.$$

The constructed function will then be presented as the following bipartite graph:

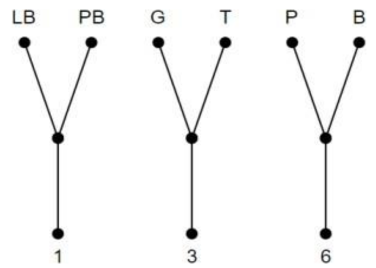

Fig.6. Graph of the relationship between z and $x2$ variables

Table 4

Studio	Branch	Adult groups			Children's groups		
		Hip-Hop	Jazz-funk	Contemporary	Hip-Hop	Jazz-funk	Contemporary
Dside	Livyi bereh	4	7	2	3		
	Pravyi bereh	10	8	3	4	1	
MyWay		2	5	1	2	1	
Mix Style	Holosiievo	3	1	2	5		1
	Troieshchyna	1	1	1	5	2	1
Dream Team		1	2	1	5	2	1
All Stars					5	10	4
Open Art	Pozniaky		1		7	7	3
	Borshchahivka		1		4	3	2
Free Way			2	1	4	2	
Dim		3	6				

The cells of Table 4 will be numbered.

Table 5

Studio	Branch	Adult groups			Children's groups		
		Hip-Hop	Jazz-funk	Contemporary	Hip-Hop	Jazz-funk	Contemporary
Dside	Livyi bereh	1	2	3	4		
	Pravyi bereh	5	6	7	8	9	
MyWay		10	11	12	13	14	
Mix Style	Holosiievo	15	16	17	18		19
	Troieshchyna	20	21	22	23	24	25
Dream Team		26	27	28	29	30	31
All Stars					32	33	34
Open Art	Pozniaky		35		36	37	38
	Borshchahivka		39		40	41	42
Free Way			43	44	45	46	
Dim		47	48				

An additional subject variable x_7 «Style» has been introduced with the following values: H – «Hip-Hop», J – «Jazz-funk», C – «Contemporary».

Next, it is necessary to express the cell numbers of Table 5, resulting in a total of 48 relations.

$x_1^{DS}x_4^{A}x_5^{LB}x_7^{H} = q_1$; $x_1^{DS}x_4^{A}x_5^{LB}x_7^{J} = q_2$; $x_1^{DS}x_4^{A}x_5^{LB}x_7^{C} = q_3$; $x_1^{DS}x_4^{K}x_5^{LB}x_7^{H} = =q_4$; $x_1^{DS}x_4^{A}x_5^{PB}x_7^{H} = q_5$; $x_1^{DS}x_4^{A}x_5^{PB}x_7^{J} = q_6$; $x_1^{DS}x_4^{A}x_5^{PB}x_7^{C} = q_7$; $x_1^{DS}x_4^{K}x_5^{PB}x_7^{H} = q_8$; $x_1^{DS}x_4^{K}x_5^{PB}x_7^{J} = q_9$; $x_1^{MW}x_4^{A}x_7^{H} = q_{10}$; $x_1^{MW}x_4^{A}x_7^{J} = q_{11}$; $x_1^{MW}x_4^{A}x_7^{C} = q_{12}$; $x_1^{MW}x_4^{K}x_7^{H} = q_{13}$; $x_1^{MW}x_4^{K}x_7^{J} = q_{14}$; $x_1^{MS}x_4^{A}x_5^{G}x_7^{H} = q_{15}$; $x_1^{MS}x_4^{A}x_5^{G}x_7^{J} = q_{16}$; $x_1^{MS}x_4^{A}x_5^{G}x_7^{C} = q_{17}$; $x_1^{MS}x_4^{K}x_5^{G}x_7^{H} = q_{18}$; $x_1^{MS}x_4^{K}x_5^{G}x_7^{C} = q_{19}$; $x_1^{MS}x_4^{A}x_5^{T}x_7^{H} = q_{20}$; $x_1^{MS}x_4^{A}x_5^{T}x_7^{J} = q_{21}$; $x_1^{MS}x_4^{A}x_5^{T}x_7^{C} = q_{22}$; $x_1^{MS}x_4^{K}x_5^{T}x_7^{H} = q_{23}$; $x_1^{MS}x_4^{K}x_5^{T}x_7^{J} =q_{24}$; $x_1^{MS}x_4^{K}x_5^{T}x_7^{C} = q_{25}$; $x_1^{DT}x_4^{A}x_7^{H} = q_{26}$; $x_1^{DT}x_4^{A}x_7^{J} = q_{27}$; $x_1^{DT}x_4^{A}x_7^{C} = q_{28}$; $x_1^{DT}x_4^{K}x_7^{H} = q_{29}$; $x_1^{DT}x_4^{K}x_7^{J} = q_{30}$; $x_1^{DT}x_4^{K}x_7^{C} = q_{31}$; $x_1^{AS}x_4^{K}x_7^{H} =q_{32}$; $x_1^{AS}x_4^{K}x_7^{J} = q_{33}$; $x_1^{AS}x_4^{K}x_7^{C} = q_{34}$; $x_1^{OA}x_4^{A}x_5^{P}x_7^{J} = q_{35}$; $x_1^{OA}x_4^{K}x_5^{P}x_7^{H} = q_{36}$; $x_1^{OA}x_4^{K}x_5^{P}x_7^{J} = q_{37}$; $x_1^{OA}x_4^{K}x_5^{P}x_7^{C} = q_{38}$; $x_1^{OA}x_4^{A}x_5^{B}x_7^{J} = q_{39}$; $x_1^{OA}x_4^{K}x_5^{B}x_7^{H} = q_{40}$; $x_1^{OA}x_4^{K}x_5^{B}x_7^{J} = q_{41}$; $x_1^{OA}x_4^{K}x_5^{B}x_7^{C} = q_{42}$; $x_1^{FW}x_4^{A}x_7^{J} = q_{43}$; $x_1^{FW}x_4^{A}x_7^{C} = q_{44}$; $x_1^{FW}x_4^{K}x_7^{H} = q_{45}$; $x_1^{FW}x_4^{K}x_7^{J} = q_{46}$; $x_1^{D}x_4^{A}x_7^{H} = q_{47}$; $x_1^{D}x_4^{A}x_7^{J} = q_{48}$.

The operation of pairwise disjunction of as many related equalities $q_1 - q_{48}$ as possible will be performed.

$$x_1^{DS}x_4^{A}x_5^{LB}(x_7^{H} \vee x_7^{J} \vee x_7^{C}) = q_1 \vee q_2 \vee q_3 = s_1 ;$$

$$x_1^{DS}x_4^{K}x_5^{LB}x_7^{H} = q_4 = s_2;$$

$$x_1^{DS}x_4^{A}x_5^{PB}(x_7^{H} \vee x_7^{J} \vee x_7^{C}) = q_5 \vee q_6 \vee q_7 = s_3;$$

$$x_1^{DS}x_4^{K}x_5^{PB}(x_7^{H} \vee x_7^{J}) = q_8 \vee q_9 =s_4;$$

$$(x_1^{MW} \vee x_1^{DT} \vee x_1^{D})x_4^{A}x_7^{H} = q_{10} \vee q_{26} \vee q_{47} = s_5;$$

$$(x_1^{MW} \vee x_1^{DT} \vee x_1^{FW} \vee x_1^{D})x_4^{A}x_7^{J} = q_{11} \vee q_{27} \vee q_{43} \vee q_{48} =s_6;$$

$$(x_1^{MW} \vee x_1^{DT} \vee x_1^{FW})x_4^{A}x_7^{C} = q_{12} \vee q_{28} \vee q_{44} = s_7;$$

$$(x_1^{MW} \vee x_1^{DT} \vee x_1^{AS} \vee x_1^{FW})x_4^{K}x_7^{H} = q_{13} \vee q_{29} \vee q_{32} \vee q_{45} = s_8;$$

$$(x_1^{MW} \vee x_1^{DT} \vee x_1^{AS} \vee x_1^{FW}) x_4^K x_7^J = q_{14} \vee q_{30} \vee q_{33} \vee q_{46} = s_9;$$
$$(x_1^{DT} \vee x_1^{AS}) x_4^K x_7^C = q_{31} \vee q_{34} = s_{10};$$
$$x_1^{MS} x_4^A x_5^G (x_7^H \vee x_7^J \vee x_7^C) = q_{15} \vee q_{16} \vee q_{17} = s_{11};$$
$$x_1^{MS} x_4^K x_5^G (x_7^H \vee x_7^C) = q_{18} \vee q_{19} = s_{12};$$
$$x_1^{MS} x_4^A x_5^T (x_7^H \vee x_7^J \vee x_7^C) = q_{20} \vee q_{21} \vee q_{22} = s_{13};$$
$$x_1^{MS} x_4^K x_5^T (x_7^H \vee x_7^J \vee x_7^C) = q_{23} \vee q_{24} \vee q_{25} = s_{14};$$
$$x_1^{OA} x_4^A (x_5^P \vee x_5^B) x_7^J = q_{35} \vee q_{39} = s_{15};$$
$$x_1^{OA} x_4^K x_5^P (x_7^H \vee x_7^J \vee x_7^C) = q_{36} \vee q_{37} \vee q_{38} = s_{16};$$
$$x_1^{OA} x_4^K x_5^B (x_7^H \vee x_7^J \vee x_7^C) = q_{40} \vee q_{41} \vee q_{42} = s_{17}.$$

Next, the corresponding binary predicates are written.

$$P_8(x_1, s) = x_1^{DS}(s^1 \vee s^2 \vee s^3 \vee s^4) \vee (x_1^{MW} \vee x_1^{DT} \vee x_1^{D}) s^5 \vee (x_1^{MW} \vee x_1^{DT} \vee x_1^{FW} \vee x_1^{D}) s^6 \vee (x_1^{MW} \vee x_1^{DT} \vee x_1^{FW}) s^7 \vee$$
$$\vee (x_1^{MW} \vee x_1^{DT} \vee x_1^{AS} \vee x_1^{FW}) s^8 \vee (x_1^{MW} \vee x_1^{DT} \vee x_1^{AS} \vee x_1^{FW}) s^9 \vee (x_1^{DT} \vee x_1^{AS}) s^{10} \vee x_1^{MS}(s^{11} \vee s^{12} \vee s^{13} \vee s^{14}) \vee$$
$$\vee x_1^{OA}(s^{15} \vee s^{16} \vee s^{17});$$
$$P_9(x_4, s) = x_4^A(s^1 \vee s^3 \vee s^5 \vee s^6 \vee s^7 \vee s^{11} \vee s^{13} \vee s^{15}) \vee x_4^K(s^2 \vee s^4 \vee s^8 \vee s^9 \vee s^{10} \vee s^{12} \vee s^{14} \vee s^{16} \vee s^{17});$$
$$P_{10}(x_5, s) = x_5^{LB}(s^1 \vee s^2) \vee x_5^{PB}(s^3 \vee s^4) \vee x_5^G(s^{11} \vee s^{12}) \vee x_5^T(s^{13} \vee s^{14}) \vee (x_5^P \vee x_5^B) s^{15} \vee x_5^P s^{16} \vee x_5^B s^{17});$$
$$P_{11}(x_7, s) = (x_7^H \vee x_7^J \vee x_7^C)(s^1 \vee s^3 \vee s^{11} \vee s^{13} \vee s^{14} \vee s^{16} \vee s^{17}) \vee (x_7^H \vee x_7^J) s^4 \vee (x_7^H \vee x_7^C) s^{12} \vee x_7^H(s^2 \vee s^5 \vee$$
$$\vee s^8) \vee x_7^J(s^6 \vee s^9 \vee s^{15}) \vee x_7^C(s^7 \vee s^{10}).$$

Thus, the multidimensional relation, with all its connections depicted in the corresponding paradigm tables, has been decomposed into 13 relations of smaller dimensions. This enables the processing of information and performing the required search simultaneously in three internal nodes of the constructed network. Thus, a mathematical model for searching dance studios has been developed in the form of a logical network. It is characterized by a composition of binary relations:

$$P(x_1, x_2, x_3, x_4, x_5, x_6, x_7, r, s, z) = P_1(x_1, r) \wedge P_2(x_2, r) \wedge P_3(x_3, r) \wedge P_4(x_4, r) \wedge P_5(x_5, r) \wedge P_6(x_1, z) \wedge P_7(x_5, z) \wedge$$
$$\wedge P_8(x_1, s) \wedge P_9(x_4, s) \wedge P_{10}(x_5, s) \wedge P_{11}(x_7, s) \wedge P_{12}(r, z) \wedge P_{13}(r, s).$$

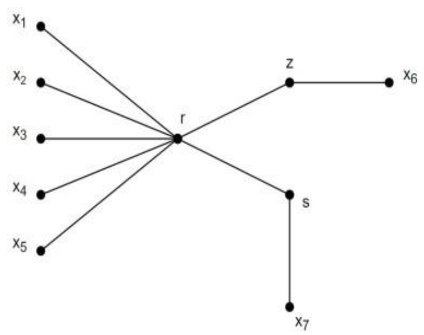

Fig.7. Logical network

Conclusions

The constructed mathematical model can be represented as a logical network. The logical network consists of poles and branches. Each pole corresponds to a specific domain variable of the model, which is referred to as the attribute of that pole. Each pole is denoted by its corresponding domain variable. Each pole is linked to its domain, which is the range of values for the attribute of that pole. Each pole of the logical network, at a given moment, carries knowledge about the value of its attribute. This knowledge is called the pole's state and is one of the subsets of the pole's domain. If the state of all poles in the network is specified at a given moment, the state of the network at that moment can be determined.

For our model, the logical network will have the following structure:

The network allows to determine the type of dance studio subscription based on the studio's location and price range.

Thus, the value of the method for constructing a logical network lies in its ability to represent a multi-place relation as a composition of binary relations. In this case, information can be processed simultaneously in several nodes in parallel. The developed model clearly demonstrates the sequence of all steps required to construct the network. However, the complexity remains in representing information about the system. Since it is necessary not only to account for all entities and their relationships but also to analyze these connections and understand what is the best way to group the features, in order to ensure that no information is neglected while simultaneously eliminating redundancy in the model [14, 15]. Clearly, a single system may correspond to multiple models [16]. Therefore, the search for the most economical and logically justified input information remains outside the scope of the logical network construction method, as it requires consultation and evaluation by experts in the relevant subject area. However, this does not diminish the significance of the method itself, which provides a mathematically grounded framework for the parallel processing of binary relations instead of sequential processing of multi-place relations, given the possibility of appropriate implementation.

The prospects for further research involve the development of a user-friendly application that would implement the constructed formal model of a logical network. The advantages of the method for constructing a logical network at the hardware level are evident, as confirmed by the model-building method itself through process parallelization and corresponding implementations in other subject areas within the scientific school of M.F. Bondarenko and Yu.P. Shabanov-Kushnarenko.

However, the task of evaluating query execution time compared to other approaches, such as SQL query generation in databases or specific machine learning methods, remains unresolved. Moreover, building various logical networks to study and identify patterns in describing subject areas during the formation of a paradigmatic table, as well as highlighting internal variables, is also of significant importance.

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