LOGICAL NETWORK MODEL WITH PREDICATE OPERATIONS

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Introduction

A universal tool based on the algebra of finite predicates for the targets and processes that operate symbolic information formalization was developed [1]. This device has been developing during 50 years and that time has proved its effectiveness in the field of artificial intelligence theory [2].

Algebra of finite predicates is complete, so by it means it is possible to describe any finite relations. The theory of finite predicate is applied and has some results on the decomposition of predicates, i.e. one-to-one transformation of predicates from one dimension to another. The transformation of system of predicates from the arbitrary finite dimension to binary system has a number of advantages in information objects and processes modeling [3]. One of them is the ability of transition from sequence to parallel algorithmic computation that is important in large computational problems. A graphical representation of binary predicate system is called logical network.

Logical network contains poles and branches. The poles are connected with the branches. Each pole matches its own individual variable x_i within the domain $A_i (i = \overline{1, m})$. A pair of poles x_i and x_j, connected by the branch $K(x_i, x_j)$, implements a linear logical operator of the first order.

The presented mathematical tool is used for intelligent structure identification [1, 2]. Such processes could be presented as a sequence of events (process actions), each of which has its own temporal label. Note that the sequence of events, not an absolute value of the label is important.

In connection with the aforesaid the problem of the arbitrary physical nature process predicate description on the base of logical networks is unresolved. This article is devoted to this problem resolution.

Modified logical network

Let's introduce such kind of construction in logical network:

$$\rightarrow (R_k(x', x_i), R_l(x', x_j), r), \qquad (1)$$

$$\begin{aligned} &\text{XOR}(R_k(x', x_i), R_l(x', x_j)) = R_k(x', x_i) \oplus R_l(x', x_j) \quad \textit{or} \\ &\text{OR}(R_k(x', x_i), R_l(x', x_j)) = R_k(x', x_i) \vee R_l(x', x_j); \end{aligned} \qquad (2)$$

$$\text{AND}(R_k(x', x_i), R_l(x', x_j)) = R_k(x', x_i) \wedge R_l(x', x_j); \qquad (3)$$

$$\Omega(R_k(x', x_i), R_l(x', x_j), t), \qquad (4)$$

that withdraws it from the generally accepted definition of logical network as a binary predicate system. Firstly, the logical network is an undirected graph while the result construction is a directed graph. Secondly, we don't use just binary predicates but either ternary. The main distinction from our point of view is the use of predicate operations, i.e. the second order predicates [4, 5] in result construction. This construction could be called logical network with predicate operations.

Graphically the resulting logical network is transformed from flat to volumetric form (Fig. 1). Such construction has a physical meaning by its ability to reflect the real procedure process separation into elementary basic actions and operations on these procedures. The obtained modification of the logical network is a natural adaptation of its structure for the investigated subject area - building a flexible process model.

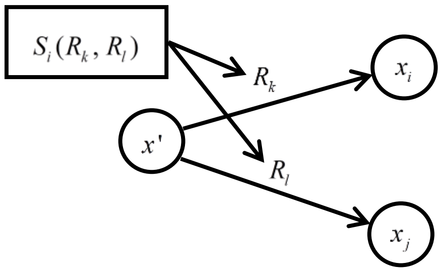

Figure 1. The logical network with predicate operation $S_i(R_k, R_l)$

The illustration of predicate representation of exclusive and non-exclusive choice and parallel execution is shown in figures 2–6.

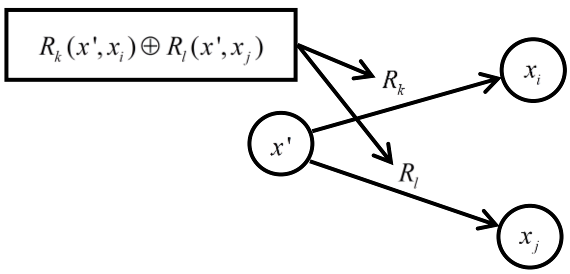

Figure 2. Exclusive choice

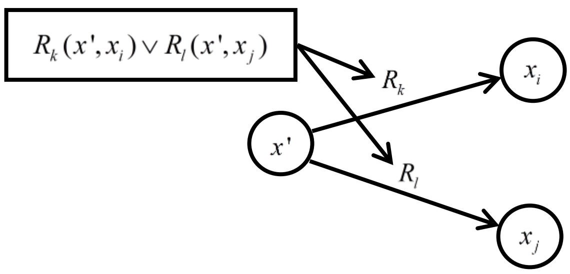

Figure 3. Non-exclusive choice

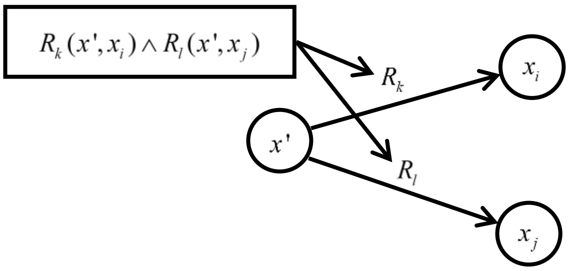

Figure 4. Parallel execution

It is important to set a sequence of vertices (from left to right), regardless of their type, for sequencing and cycle operators because the order of vertices defines the order of process actions.

In case of cycle, one vertex corresponds to the beginning of the cycle with iteration condition (it is usually corresponds to the “do” and “for” fragments).

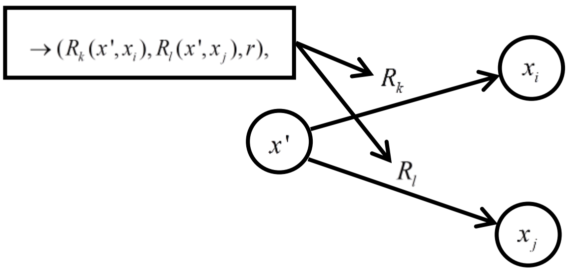

Figure 5. Sequential execution

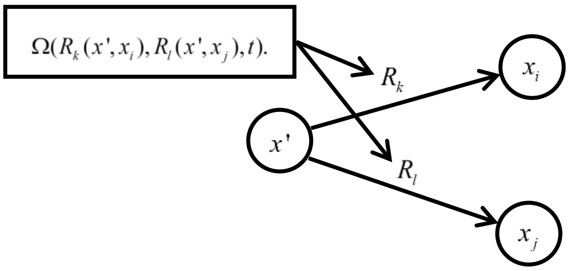

Figure 6. Predicate representation of the cycle

In general the process model is represented as a hierarchy of predicate operations of the form (1)-(4) on the top levels, and as binary predicates on the bottom level [6]:

$$M = \langle S_k, R_i \rangle, \text{ where}$$

$$R_k(x_i, x_j) \in M,\ k = \overline{1, m},\ x_i \in (V^* \cup V^{**}),\ i, j = \overline{1, n},$$

$$S_l(R_i, R_j) \in S,\ \ l = \overline{1, p}.$$

On the basis of a common process understanding, a complete model of the process must necessarily have one initial and one final state, and contain the achievement path of the final state. Mathematically, this can be described as a structure that includes:

- initial variable x_1 (model input);
- final variable x_m (model output);
- binary predicate system $R_k(x_i,x_j)$ describing the process procedure;
- predicate operations system $S_l(R_j,R_j)$;
- matrix $Z_r(R_k,t)$ defining the sequence of binary predicate calculation $R_k(x_i,x_j)$, number of step t in logical network. The number of steps is defined by the maximum length of procedure circuits in logical network;
- matrix $Z^S(S_l,t)$ defining the method of predicate operations application $S_l(R_i,R_j)$

$$M = \langle S_k, R_i, Z^R, Z^S \rangle.$$

Conclusion

In this article the model of directed logical network with predicate operations of the second order (AND, OR, XOR, loop and sequence) was proposed. The proposed modification of the logical network model has two-level structure; the second level is added for predicate operations. The implemented model provides the possibility of behavior formalization and process estimation, characterized by the sequence of actions and events. The area of practical application of the modified model is intellectual data analysis.

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