Models of Petri Nets

MODELING AND SOLVING TECHNOLOGICAL TASKS BY LANGUAGE OF PETRI NETS

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***Abstract**: The tasks of technological processes' modeling with using of Petri nets are considered in this article. Procedure of presentation and coding maxims of gas discharge circuit's filling by gas composition is shown as example of Petri nets usage. Implementation of those methods and their program realization allow getting results in a minimum time frame.*

***Keywords**: model of a gas laser, gas-discharge circuit, Petri net, graph, arc, transition, node.*

***ACM Classification Keywords**: C.*4 Performance of systems - Modeling techniques

Introduction

Graphically Petri net is a directed bipartite graph in which the nodes represent transitions (i.e. events that may occur, signified by bars) and places (i.e. conditions, signified by circles). These two types of nodes are united by the oriented arcs. By the way, every arc can be a link only for different types of nodes.

Also there are exists a notion of token or label of position. The transition is fire when in each of its input positions exist at least one token. Location of the tokens is called a marking of the net. The main lack of the Petri nets is the fact that the time of transition firing is equal to zero. [Dan'ko, 2003].

Analytical representation of Petri nets

Analytically Petri's net is represented by following way:

$$P=(B, D, I, O, M)$$

Where:

B - finite not empty set of places;

D - finite not empty set of transitions;

I:B D) r ((0, 1) – input function (direct function of incidence) specify the set of input places for every arc;

O:D B) r ((0, 1) - output function (inverse function of incidence) specify the set of output places for every arc;

M – Function of initial net marking. It set each position of a net in conformity with a non-negative integer which is equal to number of tokens in the given position.

Executing of the Petri's net is controlled by the number and distribution of tokens. The necessary condition of firing dj transition:

$$\forall b_i \in I(d_j)\{M(b_i) \geq 1\}$$

Tokens in the input position that make transition fire are named enabling tokens. Firing a transition in a marking consumes tokens from each of its input places, and produces tokens in each of its output places.

By another words, firing of the transition dj change the marking of the net M(B) on the marking M' (B) by the following rule:

$$M'(B)=M(B)-I(d_j)+O(d_j)$$

Petri nets can be described as having different degrees of liveness.

The transition dj is L0-live (dead), if it can never fire.

The transition dj is L1-live, if it may fire (i. e. there exist such M that make it enable in this marking).

The transition dj is L2-live, if it can fire arbitrarily often (i.e. if for every integer n occurs such sequence of firing where dj attends at least n times).

The transition dj is L3-live, if it can fire infinitely often (i.e. there exist the infinite sequence of firing where dj attends often without limits).

The transition dj is L4-live, if it may always fire (i.e. for every M' exists such sequence of firings that make it enable in this marking).

The transition of zero activity is passive. The transition with L4-live is active.

The main attention in analysis of Petri net is paid for the following directions:

- the reachability problem for Petri net with initial marking M0 is to decide if there exist some reachable marking M'.

- the coverage problem for given Petri net with initial marking M0 and marking M` is to decide if there exist such reachable marking M'' that $M'' \geq M'$ [Gusev, 2007].

Review of transitions liveness of the net. Liveness of the net transition implies possibility of its firing in given net with initial marking M0. Analysis of liveness allows showing prohibitive states in modeling system.

Review of persistence. The net is preserving when the number of tokens is the same after firing of any transition.

Review of net safety. The Petri net is safe if there is no any condition that make appearance more than one token in every place.

The task of gas discharge circuit's filling by gas composition

This part of article considers the tasks of using the program for modeling the process of gas-dynamic circuit filling by gas composition, where time delays are realized.

Decision of such task can be presented as:

$$HC = \{ N, D, F, \tau, Mo \},$$

where N – a directed bipartite graph (i.e. Petri net),

D – a set of tokens' descriptors,

F – load-applying reflection which consists of control and operation functions set,

τ – the function that define the time of transition opening,

M0 – initial marking of the net.

The algorithm of the task is built on the program of uniform technological processes modeling.

The class of loaded nets has high presentation ability and can generate more simple types of nets, too. So, if D = F = τ = Ø, then presented upper loaded net with marking lose its load-applying reflections and turn into the class of Petri nets. The program WinPet that is created and supported in order to make the work with Petri nets more easy belongs exactly to such class.

This program is realized and tested on real tasks of time delay modeling and design of joining computer nodes with objects. Interface of the program is shown on fig. 1.

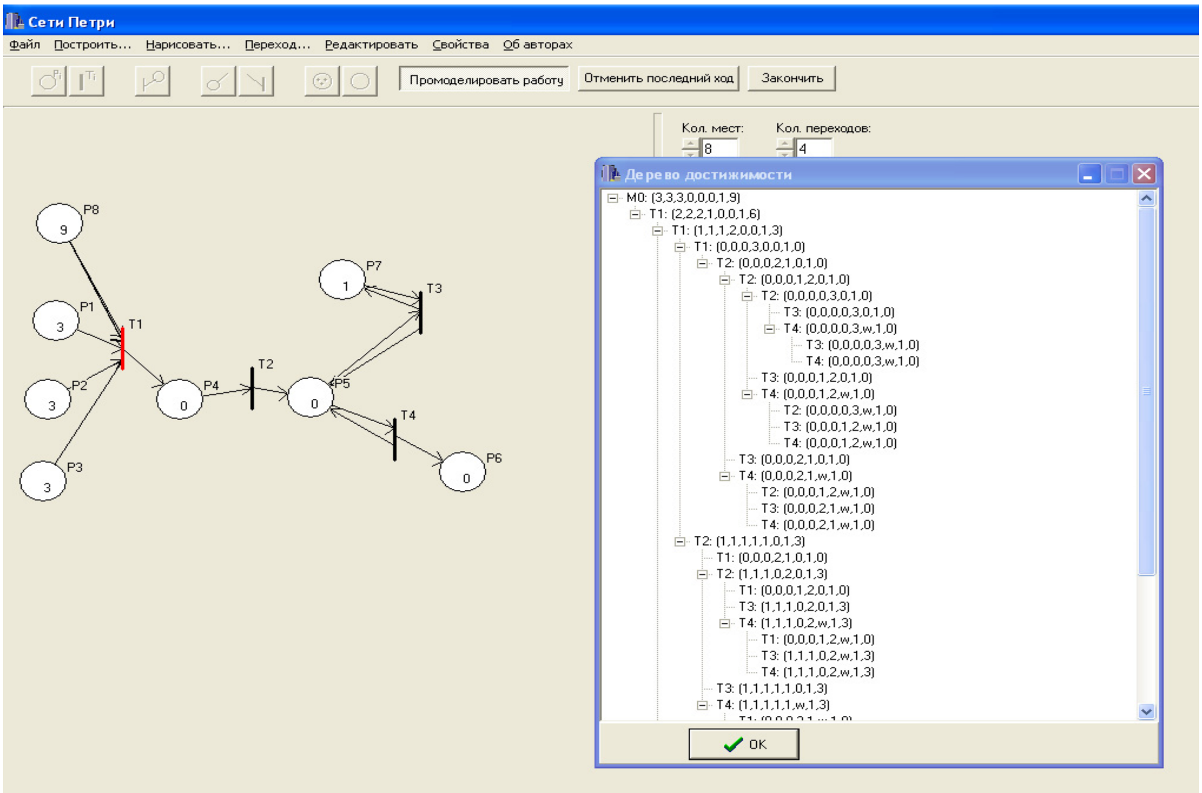

Fig. 1 – Interface of WinPet

Realized method of arcs' specifies extension of bipartite graph Petri allows to order tokens in subject to situation.

The program that represented in this article can be rate as fuzzy Petri nets in sense that allowing variation of depending on initial markup time results.

Logistic approach gives the opportunity to provide modeling of fuzzy Petri nets using this program because fuzziness is appropriated to natural language.

Program can be used by specialists in logistics as computer report document.

Evaluation of graphical abilities' rising of new graphical language class and evaluation of design labour-intensiveness comparing with program (WinPet) for Petri nets was given.

Example of gas-dynamic circuit of gas laser filling was considered for verification of examined method. The model of introduced example with using of colored Petri nets is shown on figure 2.

The method of matrix equation is very hungus and has a lot of lacks. That is why the method of reachability tree is often used.

Rreachability tree is a reachability set of Petri net. Every its node is corresponds with one of its markups.

The following method is used to make the tree of reachability not infinite. Let's consider the sequence of transition starts which has begin in markup M and end in M' >M.

M' is coincide with M except some additional tokens M'= M + (M' – M). The same sequence of transition starts can give M'' = M' + (M' – M) and so on. Let's present the infinite number of markups that is got from such type cycles by letter w which will identify infinity.

The algorithm of reachability tree building is following.

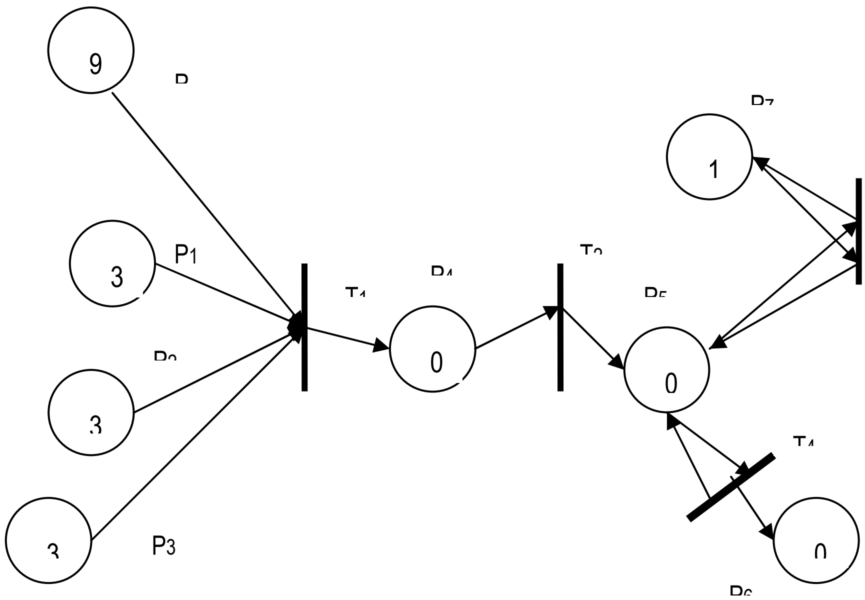

Fig. 2 - The model of introduced example

Every node is classified as boundary, terminal, duplicating and internal. Boundary node is a node which is not processed by algorithm. The algorithm converts it into terminal, duplicating or internal.

The algorithm begins from definition of root node by the input markup.

Let x will be boundary node that is necessary to treat.

1) If the tree has another node y which correspond with markup M[y]=M[x], then node is duplicating.

2) If there is no any enabled transition for the markup M[x], then x is terminal node.

3) To create new tree node z for every transition dj∈D, that is enabled in M[x]. The markup M[z], which is connected with this node, is defined for every position pi by the following way:

- if M[x]i=w, then M[z]i=w;

- If there exists the node y on the way from the root node x with M[y] < d(M[x], dj) and M[y]i < d(M[x], dj)i, then M[z]i = w.

- in another case M[z]i = d(M[x], dj)i.

Reachability tree for the task of gas discharge circuit's filling by gas composition is shown on fig. 3. The new program WinPet was used for its constructing.

Petri net is safe if and only if the letter w is absent in the tree of reachability and the largest value of the markup component that is correspond with every position, not more than one [Ovezgeldyev, 2002].

Conclusion

Implementation of described methods and their program realization allow getting result of solving the task of gas discharge circuit's filling by gas composition in a minimum time frame. Many other technical tasks can be solved by such way and give optimized parameter of the time.

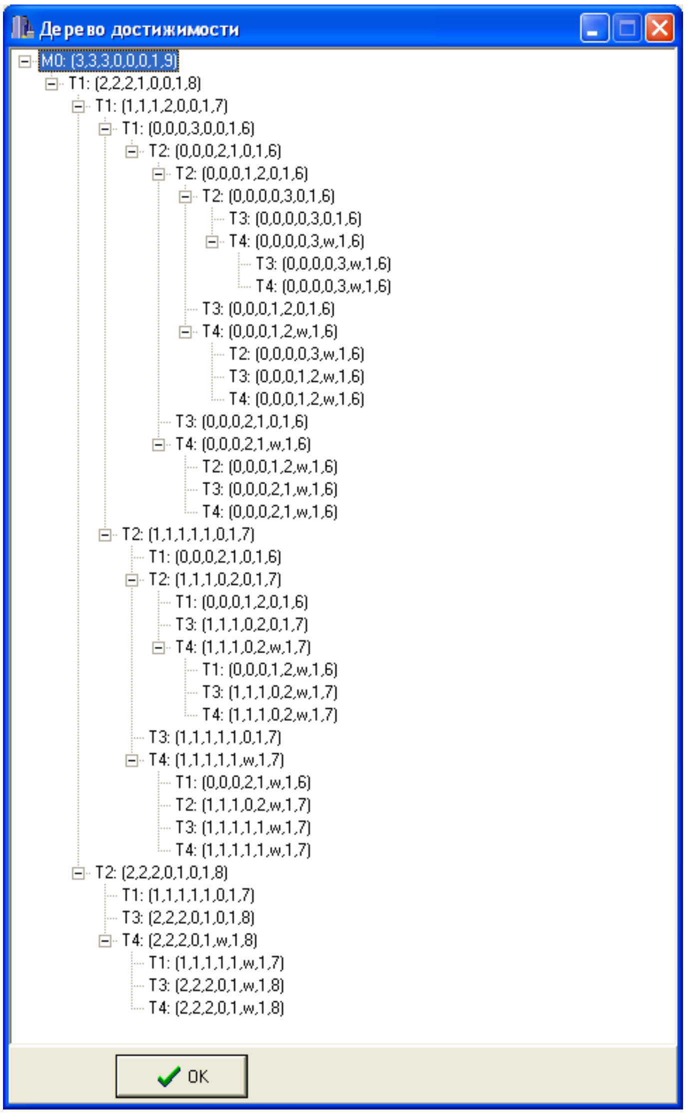

Fig. 3 - Reachability tree for the task of gas discharge circuit's filling by gas composition

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