P-graph Algorithms for Petri Net Synthesis

Rozália Lakner[1], Ferenc Friedler[1], and Botond Bertók[2]

[1] Pázmány Péter Catholic University, Budapest, Hungary
{lakner.rozalia,friedler.ferenc}@ppke.hu
[2] University of Pannonia, Veszprém, Hungary
{bertok}@dcs.uni-pannon.hu

Abstract P-graph framework provides effective algorithms to synthesize processing systems from the set of available building blocks for producing desired products. In the current work, these algorithms have been adapted for synthesizing Petri nets.

Keywords: Petri Nets, P-graph, Synthesis

Introduction Petri nets are a modeling language, that has wide range of area for description and handling concurrent, asynchronous, non-deterministic or distributed systems. Nowadays large numbers of Petri net softwares supply several built-in features both for simulation and analysis of different systems. At the same time predefined models are needed for these investigations, as Petri nets basically do not support the construction of the model.

The synthesis problem for Petri nets consists in building a Petri net satisfying a given behavioral specification. Recently there are studies dealing with the synthesis based on state transition graphs [3], [2], however these works are restricted to the subclass of the bounded choice-free Petri nets.

The synthesis, in general, is the act of determining the structure, network or flowsheet of a process, that performs as required. For algorithmic solution of process synthesis problems, a mathematically rigorous framework called P-graph was introduced by Friedler et al. [5]. The method based on the well-established combinatorial mathematics of graph theory, and a set of axioms has been formulated to express the necessary combinatorial properties to which a feasible process structure should conform [4].

P-graphs and Petri nets have similar structures based on rigorous formal mathematical definitions and graphical notations, however the two frameworks aim at different objectives of systems design. While Petri nets are introduced primarily for modeling and analysis, P-graph framework has been developed for process synthesis. Even though the objectives are quite different, it is possible to merge their capabilities in solving specific problems, e.g., synthesizing Petri nets by the P-graph framework.

Petri net synthesis by the P-graph framework The P-graph algorithms provide all of the feasible process structures. The problem is formulated by defining the set of materials and candidate operating units, characterized by their

input and output materials, as well as the flow rates of their inlet and outlet streams. The materials and the operating units in P-graph correspond to the places and transitions in Petri net, respectively. The upper bound on the availability of the raw materials and the lower bound on the required amount of desired products can be defined as well. These restrictions correspond to the partial definition of the initial state and the reachable state in the state graph of Petri net. The material rates in the P-graph are represented by arc weights in the corresponding Petri net, and the state of the P-graph is represented by tokens.

The Solution Structure Generation algorithm of P-graph framework synthesizes all the feasible solution structures exhaustively without loss of any potentially feasible structure. The union of the feasible solution structures is a (maximal) solution structure itself, that is directly constructed by eliminating the materials and operating units which cannot belong to any feasible structure according to the axioms [5]. The proposed method has been demonstrated by a simple example in Figure 1 generated by P-graph Studio software [1].

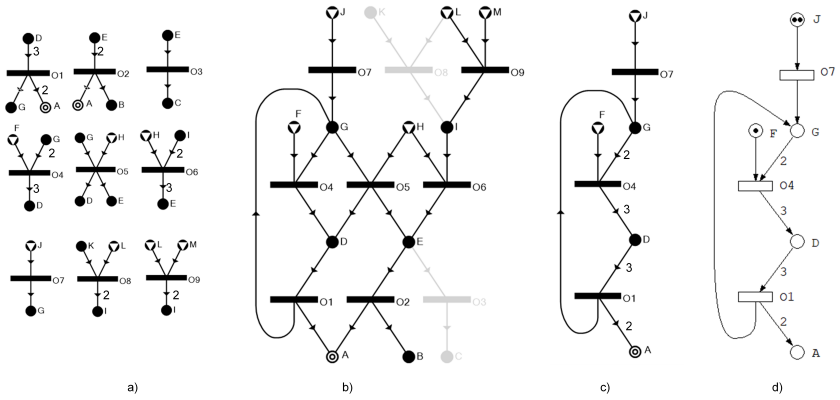

Figure 1: Petri net synthesis by P-graph algorithms
a) Problem b) Maximal structure c) A feasible structure d) Petri net

References

1. Software p-graph studio (Accessed 15/05/2015), `www.p-graph.com`
2. Badouel, E., Bernardinello, L., Darondeau, P.: Petri Net Synthesis. Text in Theoretical Computer Science, an EATCS Series, Springer (2015)
3. Best, E., Devillers, R.R.: Synthesis of bounded choice-free petri nets. Fundam. Inform. **140**(1), 39–59 (2015)
4. Friedler, F., Tarjan, K., Huang, Y., Fan, L.: Combinatorial algorithms for process synthesis. Comp. Chem.l Eng. **16**, 313–320 (1992)
5. Friedler, F., Tarjan, K., Huang, Y., Fan, L.: Graph-theoretic approach to process synthesis: Axioms and theorems. Chem. Eng. Sci. **47**(8), 1973–1988 (1992)