Algorithm for controlling the transient behavior of controlled generalized batches Petri nets

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Abstract

Discrete Petri nets (PNs) are widely used for modeling, analysis and control discrete event systems but suffer from the state explosion problem. To overcome this issue, several works have been developed on a relaxation technique so-called fluidization of Petri nets models, thus extending the discrete formalism to continuous PN. The combination of both, discrete and continuous PNs, has allowed the definition of hybrid Petri nets [1, 5]. By introducing in hybrid PNs a new kind of nodes, called batch nodes, generalized batches Petri net (GBPN) [2] enriches the class of hybrid models. Based on the concept of batches as marking, i.e., a group of entities moving through a zone at a certain speed, GBPN is appropriate for describing the behavior of high throughput production lines (control design and performance of high-speed systems), transmission delay on a communication media with bus topology, interlocking system design for ERTMS/ETCS, multimodal systems or transportation networks. In order to drive the evolution of the model, controlled GBPN (cGBPN) [4] considers as control inputs the firing flow of continuous and batch transitions and the transfer speed of batch places.

One important behavior which characterizes dynamic systems is the steady state. In a cGBPN without discrete nodes, a steady state [4] is characterized by the couple $(\boldsymbol{m}^s, \boldsymbol{\varphi}^s)$ where $\boldsymbol{m}^s$ is a constant marking and $\boldsymbol{\varphi}^s$ is constant vector of instantaneous firing flows.

Our objective is to control the transient trajectory of a cGBPN. By assuming that there are no discrete nodes and all transitions are controllable, the problem is how to reach a target steady state $(\boldsymbol{m}^s, \boldsymbol{\varphi}^s)$ from a given initial marking $\boldsymbol{m}_0$, by controlling only the instantaneous firing flow of transitions. Much efforts have been devoted to the control design for trajectory tracking with continuous Petri nets [7] while few works have been conducted on hybrid PNs [6] or cGBPNs [3].

Inspired by the ON/OFF strategy developed in [7], an algorithm dedicated to cGBPN is proposed for computing the control trajectory incrementally. At the initial marking $\boldsymbol{m}_0$, all instantaneous firing flows of continuous and batch transitions are set to zero (OFF). Next, the set of enabled transitions is determined. If some specific conditions on the batch marking are respected, enabled transition t_j becomes ON, and its instantaneous firing flow takes its steady state value, i.e. $\varphi_j = \varphi_j^s$. Then, the next events (i.e., the nearest in time) is computed and the marking is updated. We repeat the process until the target steady state is reached.

References

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