MARKING OPTIMIZATION IN TIMED EVENT GRAPHS

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ABSTRACT:
This paper addresses the marking optimization problem in a strongly connected timed event graph. It consists in finding an initial marking such that the cycle time is smaller than a given value and that an invariant linear criterion is minimized. This linear criterion is based on a p-invariant of the strongly connected event graph under consideration. We prove some properties of the optimal solution and provide a heuristic algorithm which gives near optimal solution to the problem. Applications of the results to the work-in-process optimization of job-shops and Kanban systems are proposed.

KEYWORDS:
1. INTRODUCTION

Petri nets are well-known as efficient tools for modelling discrete event systems, and particularly manufacturing systems. In particular, Petri nets are able to represent synchronous events, asynchronous concurrent processes. An excellent survey on the subject can be found in MURATA [5] and the related references.

Timed Petri nets have been introduced to model duration of activities and, as a consequence, to represent the dynamic behaviour of discrete systems. Timed event graphs, a special type of Petri nets, have been proven to be adequate for modelling job-shops and assembly systems when the production is periodic (see for instance HILLION and PROTH [3] and HILLION et al. [4]).

The properties of the timed event graphs have been extensively studied by RAMCHANDANI [6], SIFAKIS [8], RAMAMOORTHY and HO [7] and CHRETIENNE [1].

All the previous works are related to deterministic event graphs, i.e. to event graphs in which the times assigned to the transitions are deterministic. This work makes the same assumption.

A challenging problem arising in this context is to reach a cycle time smaller than a given value while minimizing an invariant linear criterion. Such a criterion is a linear combination of the number of tokens in the places at the initial time. Its value remains constant by transition firings (assuming that tokens remain in the places preceding the transitions fired until the transition firing terminates).

In this paper, we assume that the basics of timed event graphs are known from the part of the reader as presented in HILLION and PROTH [3].

Section 2 introduces the problem at hand. In section 3, we discuss the properties of the optimal solutions. A heuristic algorithm which leads to a near optimal solution to the problem is given in section 4. Finally, applications in the field of work-in-process of manufacturing systems are presented in section 5.

2. PROBLEM DESCRIPTION

2.1. Preliminary assessment

Let N = (P,T,F) be the strongly connected event graph considered. P is the set of places, T is the set of transitions and F C (P x T) U (T x P) the set of directed arcs. We denote by M₀ the initial marking of N. For every t ∈ T, τₜ is the transition firing time of t (τₜ is a positive rational number). We assume that a transition cannot be fired by more than one token at any time. In other words, a transition in a firing execution is not enabled for a new firing. This restriction can be explicitly modelled by adding a self-loop with one token to each transition of the net as shown in figure 1.