

Using Interval Constrained Petri Nets for Regulation of Quality: The Case of Weight in Tobacco Factory

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Abstract- The existence of maximal durations drastically modifies the performance evaluation in Discrete Event Systems (DES). The same particularity may be found on systems where the associated constraints do not concern the time. For example weight measures, in chemical industry, are used in order to control the quantity of consumed raw materials. This parameter also takes a fundamental part in the product quality as the correct transformation process is based upon a given percentage of each essence. Weight regulation therefore increases the global productivity of the system by decreasing the quantity of rejected products. The main contribution of this paper is to describe the behaviour of the Interval Constrained Petri Nets (ICPN). Their basic evolution rules are presented and the extension of the P-time PN structural analysis is discussed. An industrial application on a tobacco manufacturing plant, where the critical parameter is the weight is presented as an illustration.

Index terms: Petri Net, Manufacturing systems, Performance evaluation, Timed Petri Nets, Tolerant system.

1. INTRODUCTION

Manufacturing systems and particularly chemical and food industries are based on time constrained processes. More precisely, these processes are performed during certain time windows. Modelling such processes must specify, for every operation, either a minimal duration or an operating duration included in a time window, in order to ensure the product quality. Several studies describe appropriate models based on Timed Petri Nets and are able to model processes with time constraints [1, 2]. In the category of the workshops, the operations have temporal constraints that must be imperatively respected. The violation of these constraints can damage the health of consumers. The constraint violation causes a deterioration of quality or the stop of production.

In many processes, the deciding parameter for the quality and the cost is not time. However, this parameter must strictly belong to some validity intervals. The control must guarantee the fulfilment of these specifications. So a suitable model, rich in

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analytical properties, is necessary to synthesize the needed controller.

The aim of this paper is to explain the use of Interval Constrained Petri Nets (ICPN) a sub-class of High Level Petri Nets with Abstract Marking (AM-HLPN) [3, 4]. ICPN allow one to model and guarantee a constraint on any parameter of a manufacturing process. They are applied to a tobacco factory unit where the speed of machines is constant. We ensure the product quality by verifying weight specifications. The production is optimised by minimizing losses in presence of variation.

First we introduce ICPN that are a functional abstraction of P-Time Petri Nets [1]. In this way, the extension of structural properties of P-Time PN can be justified under some conditions [5]. A theorem application is extended to our case study and will be illustrated in a practical manner.

2. INTERVAL CONSTRAINED PETRI NET

ICPN are introduced to extend the application field of P-Time PN by proceeding to a functional abstraction of the parameter associated places. Naturally, it is logical to find exactly the same mathematical definition of the tool. Nevertheless, if the restriction of the associated parameter to rational numbers is justified when this one is duration, it has no more justification in the case of modelling weight variation or position. Such parameters may take both negative and positive values.

Furthermore, the introduction of a new formalism is an opportunity to review the initial definition. Thus, we present in an unequivocal manner the marking as a multi-set. In the same way the transmission of a quantity conveyed by a token is represented explicitly.

2.1 Definition

An Interval Constrained Petri Net is an 8-uple $\langle R, M, IS, D, Val, Val_0, X, X_0 \rangle$ where:

- R is a marked Petri net [6],
- M is an application associating tokens to places as follow:

Let $m(p)$ be a place marking.

Let Va be a set of rational variables.

