Chapter 8

Modelling Formalisms for Green Transportation Systems

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ABSTRACT

Protection of environment implies the coordination of the local and regional authorities to implement actions for conservation of all natural resources in the actual context of globalisation. One of the most important direction for applying the above mentioned desiderates is a better planning of transportation, as we all know that globalisation implies an accelerated process of externalisation of ideas, know-how, products and labours. In this chapter, we consider discrete event systems (DES) modeled via a state space representation. The model objective is the avoidance of a given set of states, or equivalently the fact that certain predicates, specified in terms of states are always false. We address the state space controlled Petri Nets (PN) and a technique to reduce the complexity of these nets, by taking into account the fact that the complexity of the considered nets depends mainly on the representation of the control design, respectively on the forbidden sets of places. Our goal is to describe in an efficient way the forbidden sets of the modeled system, e.g. to describe in an efficient way the DES modeled with controlled Petri nets. An example from the railway systems illustrates this approach.

INTRODUCTION

In this chapter, we consider discrete event systems (DES) modeled via a state space representation. The model objective is the avoidance of a given set of states, or equivalently the fact that certain predicates, specified in terms of states are always false. We address the state space controlled Petri Nets (PN) and a technique to reduce the complexity of these nets, by taking into account the fact that the complexity of the considered nets depends mainly on the representation of the control design, respectively on the forbidden sets of places (Laftit, 1992). Our goal is to describe in an efficient way the forbidden sets of the modeled system, e.g. to describe in an efficient way the DES modeled with controlled Petri nets (Yee & Ventura, 2000). An example from the railway systems illustrates this approach: the Petri net model of railway station incompatible tracts. We mention that every railway station has such a table,
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given to the general traffic rules allocated to a certain station. A railway transport system consists of several concurrent units such as railway engines, wagons, automated guided vehicles, logic controllers, which function asynchronously to meet the dynamically changing needs of the transport plan. Methods aiming for modelling, analysis, control and simulation of such systems are important. The typical functions of the control are to sequence the operations, monitor the system functioning, and determine the states of different elements in a transport system in respect to real time. Petri nets graphically describe the system behavior in terms of the successive states realized after the occurrence of events. Events correspond to a change from one state to the next state. The number of tokens in each place represents the state of the Petri net. When a transition fires, tokens are moved from one place to another place. The firing of a transition corresponds to an event. In a controlled Petri net, the transitions fire only when all their input control places are marked. The control objective is to prevent a set of forbidden states from being reached, while at the same time enabling a maximal set of achievable state sequences. The PNs property to allow a graphical and analytical representation, closely related to the technological process being modeled, makes them a very useful tool for enabling the application of the theory. We address our work with a comparison between two most used formalisms for modeling manufacturing systems, including transportation ones: Timed Petri Nets (TPN) versus Ladder Diagrams (LLD) (Falcione & Krogh, 1993). We notice that as the specification changes, the TPN requires fewer changes compared to the LLD. Using TPNs the control logic can be qualitatively analyzed to check properties such as absence of deadlocks and presence of reversibility in the system. Using LLDs qualitative analysis is not possible until it is stimulated or implemented. Using TPNs, the initial state of the system can be directly represented by its initial marking. The procedure for controlling a system using TPNs is straightforward, simple, and can be applied to control any discrete event system that has digital in/out interface and a computer. Adding more attributes to places and transitions can extend TPNs in order to control complex transport systems. Designing a discrete event controller with choices to perform a control task can extend the present approach.

2. CONTROLLED PETRI NETS

2.1 Basic Properties

A controlled Petri net is defined as a five-tuple $G=(P, T, F, C, B)$, where $P$ and $T$ are finite sets of state places and transitions, respectively; $F \subseteq (PxT) \cup (TxP)$ is a set of directed arcs connecting state places and transitions; $C$ is a finite set of control places; $B \subseteq (CxT)$ is a set of directed arcs associating control places with transitions. A state place $p\in P$ is said to be an input to (respectively output from) transition $t\in T$ if $(p, t) \in F$ (respectively $(t, p) \in F$). Denote by $I^p$, respectively $O^p$ the sets of these input, respectively output places. The sets $I^c$, $O^c$, $C^c$, and $I^t$ are defined similarly. Each controllable transition is influenced by one control place and this control place influences only this one single transition. A control $u: C \rightarrow \{0, 1\}$ indicates whether control place $c$ is marked or not ($u(c) = 1$ or $0$). Two special controls are $u(c) = 1$, $\forall c$, enabling all transitions, and $u(c) = 0$, $\forall c$, disabling all controllable transitions. A transition, in a controlled Petri net, is enabled if it is both state and control enabled, that means that under marking $m$ must have: $m(p) \geq 1$, $\forall p \in I^t$, $t$ fires, a token can be removed from