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On the Modeling and Control of extended Timed Event Graphs in Dioids

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Abstract

Various kinds of manufacturing systems can be modeled and analyzed by Timed Event Graphs (TEGs). These TEGs are a particular class of timed Discrete Event Systems (DESs), whose dynamic behavior is characterized only by synchronization and saturation phenomena. A major advantage of TEGs over many other timed DES models is that their earliest behavior can be described by linear equations in some tropical algebra structures called dioids. This has led to a broad theory for linear systems over dioids where many concepts of standard systems theory were introduced for TEGs. For instance, with the (max,+)-algebra linear state-space models for TEGs were established. These linear models provide an elegant way to do performance evaluation for TEGs. Moreover, based on transfer functions in dioids several control problems for TEGs were addressed. However, the properties of TEGs, and thus the systems which can be described by TEGs, are limited. To enrich these properties, two main extensions for TEGs were introduced. First, Weighted Timed Event Graphs (WTEGs) which, in contrast to ordinary TEGs, exhibit event-variant behaviors. In WTEGs integer weights are considered on the arcs whereas TEGs are restricted to unitary weights. For instance, these integer weights make it straightforward to model a cutting process in a production line. Second, a new kind of synchronization called partial synchronization (PS) was introduced for TEGs. PS is useful to model systems where specific events can only occur in a particular time window. For example, consider a crossroad controlled by a traffic light: the green phase of the traffic light provides a time window in which a vehicle is allowed to cross. Clearly, PS leads to time-variant behavior. As a consequence, WTEGs and TEGs under PS are not (max,+)-linear anymore.
In this thesis, WTEGs and TEGs under PS are studied in a dioid structure. Based on these dioid models for WTEGs a decomposition of the dynamic behavior into an event-variant and an event-invariant part is proposed. Under some assumptions, it is shown that the event variant part is invertible. Hence, based on this model, optimal control and model reference control, which are well known for ordinary TEGs, are generalized to WTEGs. Similarly, a decomposition model is introduced for TEGs under PS in which the dynamic behavior is decomposed into a time-variant and time-invariant part. Again, under some assumptions, it is shown that the time-variant part is invertible. Subsequently, optimal control, as well as model reference control for TEGs under PS is addressed.