Structuring multilevel discrete-event systems modeled with extended finite state automata

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1 Introduction

The complexity of high-tech systems has increased due to increasing market demand for verified safety, shorter time-to-market, and better performance. Model-based systems engineering approaches provide advantages for supervisory controller design. We consider discrete-event system (DES) models for which supervisory controllers need to be developed. The supervisory control theory of Ramadge-Wonham provides an approach to synthesize supervisors such that the controlled behavior of the system is restricted to specified behavior [1].

One of the major drawbacks of synthesizing supervisory controllers is the step where the supremal controllable language is calculated. There exist multiple attempts to overcome these computational difficulties. One of them is multilevel supervisory control synthesis [2]. A problem with multilevel synthesis is that the system should be modeled with a tree structure.

Recently, we proposed to use Dependency Structure Matrices (DSMs) to exploit the dependencies within a system to transform it into the tree structure needed for multilevel synthesis [3]. We analyze the relationship between the plant models and requirement models. For finite state automata, there is a relationship between a plant model and a requirement model when they share an event.

2 Result

We propose to enrich the method from [3] to analyze extended finite state automata (EFSAs). In EFSAs, discrete variables can be used and guards on edges can refer to locations in other EFSAs. Furthermore, requirement models can be formulated with state-based expressions.

For EFSAs, there is a relationship between a plant model and a requirement model if they share an event, share a variable, or the requirement refers to a location in the plant model.

We are able to structure DES models of industrial-size systems using EFSAs. An example of such system is a waterway lock as presented in [4]. Figure 1 shows the clustered DSM of this waterway lock.

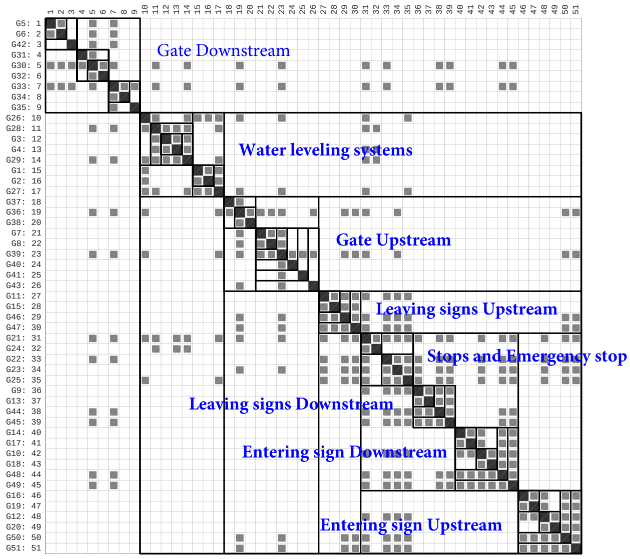

Figure 1: The clustered DSM of a waterway lock

By using multilevel synthesis in combination with DSM-based clustering, we can reduce the state-space size. The uncontrolled state-space has 6.0×10^{32} states. The monolithic supervisor for this system has 6.0×10^{24} states. For multilevel synthesis, we can reduce the state-space of the supervisors together to 3.5×10^{7} states.

References

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