Deadlock analysis in hierarchical Petri nets

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The existence of deadlocks in bounded hierarchical Petri nets is investigated in this paper. Both the existence of deadlocks and boundedness are related behavioural properties [1] of great practical importance.

As the analysis of behavioural properties is a computationally hard problem, therefore we usually structure a huge Petri net with many elements using hierarchical decomposition. This way we hope to conclude about the analysis results for the overall net from the results for the subnets and from the way they are composed together. The structuring obeys strict syntactical rules. It is an important technical assumption in this paper that a two-level hierarchy is assumed for the decomposition.

In order to solve the problem in an abstract way, a formal description of the Petri net together with a formal description of the composition net is needed [2]. The composition net plays an important role in evaluating the analysis results of the Petri subnets.

The proposed deadlock detection algorithm is based upon the hierarchical structure and on the deadlock analysis of the subnets using Boolean algebra. Two basic cases have been identified in the design of the algorithms: the case of safe (1-bounded) Petri nets and the k-bounded Petri net case [3, 4].

Boolean variables are used for describing the Petri nets. The first case, the case of safe Petri nets is considered as a basic case. In order to handle k-bounded Petri nets, the basic case has been modified so that Boolean variables could be used. Therefore binary encoding is applied in order to be able to use Boolean variables.

Both the hierarchical deadlock detection and the conventional (without hierarchical decomposition) deadlock detection algorithms are implemented in Matlab. The computational complexity of the resulted algorithms and their applicability conditions are also analyzed [5]. It has been concluded that the deadlock analysis with hierarchical decomposition is faster than that without hierarchical decomposition given the limits on the structure of the Petri net (the number of its elements and the range of k).

References

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