Discrete event system optimization through Automata/FSM Equation Solving

Nina Yevtushenko

The optimization problem for discrete event systems, in particular, for digital circuits, is well known and remains a challenging problem for developing new information technologies. When a system has a modular structure, the best approach for its optimization seems to be an iterative optimization along with a checking at each step for conformance and improvement. Such an approach can be done based on solving an automata/FSM equation $X \bullet Context \subseteq Spec$. (This equation has to be solved in order to capture all the machines that combined with all other component machines (*Context*) keep the reference behavior *Spec* of the overall composition.) A general solution to this equation can be viewed as a reservoir for all possible implementations of a component of interest, from which an optimal implementation can be chosen with respect to design criteria such as reliability, fault-tolerance, minimal number of communication lines, delay, area, etc. The main problem to apply the approach is the formidable computational complexity as the *Context* and *Spec* are too sophisticated in practical sequential circuits. To decrease the complexity, a windowing approach is proposed, where a component is optimized only with respect to its immediate neighbor modules. In this case, a single equation is replaced by a collection of smaller equations.

Working together (partially under support of Linkage NATO grants and joint RFBR-NNC grants), the groups of R. K. Brayton (U.C., Berkeley), N. V. Yevtushenko (Tomsk S.U.) and T. Villa and A.L. Sangiovanni-Vincentelli (Parades, Rome, currently Verona University and U.C., Berkeley) A. Petrenko (CRIM, Canada), Jiang Jie-Hong (National Taiwan University) we pioneered the approach for equation solving based on language equations, have characterized solvability of automata/FSM equations and showed how to compute effectively a largest solution (any other solution is a reduction of the largest solution); we also characterized some restricted solutions of practical interest. Software tools were implemented for solving equations over digital circuits that allow us to deal with small to medium-sized systems. Our experiments with benchmarks clearly show that many circuits which are not optimized using other approaches can be optimized through solving FSM/automata equations.

However, currently, only some straightforward restricted solutions have been identified. Moreover, there are other problems that remain to be solved for this approach to be applicable to real discrete event systems, as large digital circuits, discrete supervisors etc. The main purpose of this international cooperation project could be to develop a set of efficient algorithms as well as software tools to drive the logic optimization of control units meeting various design requirements.

Reference

1. T.Villa, N.Yevtushenko, R.K.Brayton, A.Mishenko, A.Petrenko, A.L. Sangiovanni-Vincentelli 'The Unknown Component Problem: Theory and Applications', Springer, 2011 (in press).