Functional Equivalence of Combinatorial Logic Networks

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EXTENDED ABSTRACT

The problem of function equivalence of combinatorial logic networks is the problem of decision whether two different circuits realize the same logical function. This problem arises in several areas like verification, logic synthesis and evolvable hardware (EH).

In order for two logical circuits to be equivalent their output functions have to be equivalent under the permutation of all logical inputs and outputs. The simplest method to determine whether two combinatorial logic networks with *n* inputs and *m* outputs are equivalent would be to enumerate all *n!m!* possible matches. This approach is however computationally infeasible for larger instances. It turns out that the function equivalence checking is a NP hard problem, however several approaches have evolved to tackle this problem.

Most of these approaches are based on representation of logic circuit as Boolean function in canonical form. It is said, that two functions are equivalent if their canonical representation of their output functions are equivalent. The Reduced Order Binary Decision Diagrams (ROBDD) is widely used canonical representation in the field of formal verification. Determining whether two logic circuits represent equal Boolean functions is done by means of determining whether two corresponding ROBDDs are isomorphic. There are several techniques for solving this, but for practical purposes, only graphs with relatively small number of nodes can be compared.

Alternative approaches emerging from modern computer science utilize satisfiability (SAT) solvers. These SAT solvers were drastically improved over last few years and as result, SAT-based equivalence checking is being used as promising alternative to BDD based checking. For SAT-based checking it is necessary to express logical function of combinatorial logical circuit in conjunctive normal form (CNF), which could be a problem of its own.

In this work, we will discuss approach to transformation of combinatorial logic network representation into CNF form by utilizing Tseitin's algorithm. Next, we will discuss usability of this approach in EH field. And finally we will discuss usability and other implications of SAT-based checking in general.