Constrained Horn Clauses for Program Verification and Synthesis (Invited Talk)

Arie Gurfinkel

University of Waterloo, Waterloo, Canada

Abstract

First-Order Logic (FOL) is a powerful formalism that naturally captures a wide range of decision and optimization problems. Over the past two decades, automated reasoning tools such as SAT and Satisfiability Modulo Theories (SMT) solvers have advanced dramatically, making logic-based approaches practical for many applications in computer science and program analysis. Today, many program analysis techniques formulate their verification tasks as logical constraints and rely on SAT or SMT solvers to reason about them automatically.

In this talk, we focus on a fragment of FOL known as Constrained Horn Clauses (CHCs) and on SPACER, a state-of-the-art CHC solver. CHCs arise naturally in many verification and synthesis applications, including the discovery and verification of inductive invariants, safety verification of finite- and infinite-state systems, model checking of pushdown systems and their extensions, modular verification of distributed and parameterized systems, type inference, and many others.

A key advantage of the CHC-based approach is the separation of proof methodology from proof search. Verification tasks are first encoded as CHCs through the generation of Verification Conditions (VCs), while the responsibility for solving these conditions is delegated to a CHC solver. This separation enables a single framework to support multiple proof methodologies, programming languages, and verification tasks, while maintaining high performance and scalability.

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arie.gurfinkel@uwaterloo.ca (A. Gurfinkel)