Deciding First-Order Theory of Integers with Addition Using Automata

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The ability to algorithmically decide whether a given formula has a model is valuable to many areas of compiler construction and formal verification. It allows one to automatically prove that a given code optimisation is sound, to detect unintentional overflows, and to highlight other potential defects in a given program. Decision procedures—algorithms designed to determine the existence of a model—are an active research area, and their implementations are being employed in the industry, e.g., to reason about the correctness of configuration of critical infrastructure. This talk focuses on a decision procedure for the first-order theory of integers with addition (so called Presburger arithmetic) based on the formal model of finite automata. After a high-level description of the decision procedure and its caveats, the talk will discuss the challenges of crafting a modern and performant implementation that supports a standardized input language SMT-LIB. In this setting, the implementation can be seen as an interpreter of first-order formulae where expression values range over automata. Finally, an overview of the recent advancements based on a tight integration of formula-based reasoning and automata will be presented along with open problems.