Programming Language Expressiveness and Circuit Complexity

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Abstract

This paper is a continuation of the work begun in [5] on establishing relative *intensional expressiveness* results for programming languages. Language L_1 is intensionally more expressive than L_2, if L_1 can compute all the functions L_2 can, with at least the same asymptotic complexity. The question we address is: Does nondeterministic parallelism add intensional expressiveness? We compare deterministic and nondeterministic extensions of PCF, a simple functional programming language. We develop further the circuit semantics from our earlier work, and establish a connection between parallel PCF programs and boolean circuits. Using results from circuit complexity, and assuming hardware which can detect undefined inputs, we show that nondeterministic parallelism is indeed intensionally more expressive. More precisely, we show that nondeterministic parallelism can lead to exponentially faster programs, and also programs that do exponentially less work.