Milner's Proof System for Regular Expressions Modulo Bisimilarity is Complete

Crystallization: Near-Collapsing Process Graph Interpretations of Regular Expressions

Anonymous Author(s)

Abstract

Milner (1984) defined a process semantics for regular expressions. He formulated a sound proof system for bisimilarity of process interpretations of regular expressions, and asked whether this system is complete.

We report on a lengthy proof that establishes that Milner's system is complete, by motivating and describing all of its main steps. We substantially refine the completeness proof by Grabmayer and Fokkink (2020) for the restriction of Milner's system to '1-free' regular expressions. As a crucial complication we recognize that process graphs with empty-step transitions that satisfy the layered loop-existence/elimination property LLEE are not closed under bisimulation collapse (unlike process graphs with LLEE that only have proper-step transitions). We circumnavigate this obstacle by defining a LLEE-preserving 'crystallization procedure' for such process graphs. By that we obtain 'near-collapsed' process graphs with LLEE whose strongly connected components are either collapsed or of 'twin-crystal' shape. Such near-collapsed process graphs guarantee provable solutions for bisimulation collapses of process interpretations of regular expressions.