A Linear Logical Framework in Hybrid

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Abstract

We present a linear logical framework implemented within the Hybrid system [2]. Hybrid is designed to support the use of higher-order abstract syntax for representing and reasoning about formal systems, implemented in the Coq Proof Assistant. In this work, we extend the system with two linear specification logics, which provide infrastructure for reasoning directly about object languages with linear features.

We originally developed this framework in order to address the challenges of reasoning about the type system of a quantum lambda calculus. In particular, we started by considering the Proto-Quipper language [6], which contains the core of Quipper [3, 7]. Quipper is a relatively new quantum programming language under active development with a linear type system. We have completed a formal proof of type soundness for Proto-Quipper [5]. Our current work includes extending this work to other properties of Proto-Quipper, reasoning about other quantum programming languages [4], and reasoning about other languages such as the meta-theory of low-level abstract machine code.

We are also interested in applying this framework to applications outside the domain of meta-theory of programming languages and have focused on two areas – formal reasoning about the proof theory of focused linear sequent calculi and modeling biological processes as transition systems and proving properties about them. We found that a slight extension of the initial linear specification logic allowed us to provide succinct encodings and facilitate reasoning in these new domains. We illustrate by discussing a model of breast cancer progression as a set of transition rules and proving properties about this model [1]. Current work also includes modeling stem cells as they mature into different types of blood cells.

This work illustrates the use of Hybrid as a meta-logical framework for fast prototyping of logical frameworks, which is achieved by defining inference rules of a specification logic inductively in Coq and building a library of definitions and lemmas used to reason about a class of object logics. Our focus here is on linear specification logics and their applications.

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Category Invited Talk

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