Reasoning About Deductions in Linear Logic
(Invited Talk)

Frank Pfenning

Carnegie Mellon University
School of Computer Science
fp@cs.cmu.edu

Linear logic has been described as a logic of state. Many complex systems involving state transitions, such as imperative programming languages, concurrent systems, protocols, planning problems, games, or abstract machines, can be specified in linear logic at a very high level of abstraction. Generally, these encodings represent legal sequences of transitions as deductions in linear logic.

Proof search in linear logic then allows us to establish the existence of transition sequences, thereby, for example, solving a planning problem or modelling the execution of a protocol. But we often need to consider all possible computations, for example, to establish that an imperative programming language is type-safe or that a protocol is secure. This then requires reasoning about deductions in linear logic.

We describe our approach to proving properties of deductions in linear logic which is based on the linear logical framework LLF [CP96] and an explicit meta-logic with universal and existential quantifiers ranging over proof objects. Due to the immediacy of the encodings, the expressive power of the linear logical framework, and the design of the meta-logic this architecture offers excellent opportunities for automation, combining techniques from type theory, constraint logic programming, and inductive theorem proving. In the interactive setting, a related architecture has been proposed by McDowell [McD97] and applied to a less expressive linear framework.

Preliminary results with a non-linear prototype [SP98] have been very encouraging and include, for example, automatic proofs of Hilbert's deduction theorem, type preservation for mini-ML, and soundness and completeness of logic programming search.

References

[CP96] Iliano Cervesato and Frank Pfenning. A linear logical framework. In E. Clarke, editor, *Proceedings of the Eleventh Annual Symposium on Logic in Computer Science*, pages 264–275, New Brunswick, New Jersey, July 1996. IEEE Computer Society Press.

[McD97] Raymond McDowell. *Reasoning in a logic with definitions and induction.* PhD thesis, University of Pennsylvania, 1997.

[SP98] Carsten Schürmann and Frank Pfenning. Automated theorem proving in a simple meta-logic for LF, 1998. This volume. An extended version is available as Technical Report CMU-CS-98-123, Carnegie Mellon University.