

The Practice and Promise of Substructural Frameworks

Frank Pfenning

Carnegie Mellon University
Pittsburgh, Pennsylvania, USA
fp@cs.cmu.edu

Logical frameworks are based on the premise that fundamental concepts and constructions in the definition of logics and programming languages should be directly supported in the framework. For LF, these include variable binding, substitution, as well as parametric and hypothetical judgments. Absent are intrinsic notions of state, consumable resource, or concurrency, which appear to be similarly fundamental. Integrating these into logical frameworks has led to the development of substructural frameworks such as LLF (linear) [1], RLF (relevant) [3], OLF (ordered) [7], CLF (concurrent) [13, 2] and HLF (hybrid) [9]. Recent implementations such as Lollimon [4], Celf [10], and HLF [9] have allowed us to gain some experience with using these languages [8, 14, 15, 11, 12].

A promising related specification technique for programming languages is substructural operational semantics (SSOS) [5, 6]. We illustrate this technique and the logical framework features that support it through several sample programming constructs. We also sketch our current approach to analyzing such specifications, which has been the most challenging part in the development of the next generation of logical frameworks.

Acknowledgments

This talk presents joint work with Jason C. Reed and Robert J. Simmons.

References

- [1] Iliano Cervesato & Frank Pfenning (2002): *A Linear Logical Framework*. *Information & Computation* 179(1), pp. 19–75. Revised and expanded version of an extended abstract, LICS 1996, pp. 264–275.
- [2] Iliano Cervesato, Frank Pfenning, David Walker & Kevin Watkins (2002): *A Concurrent Logical Framework II: Examples and Applications*. Technical Report CMU-CS-02-102, Department of Computer Science, Carnegie Mellon University. Revised May 2003.
- [3] Samin Ishtiaq & David Pym (1998): *A Relevant Analysis of Natural Deduction*. *Journal of Logic and Computation* 8(6), pp. 809–838.
- [4] Pablo López, Frank Pfenning, Jeff Polakow & Kevin Watkins (2005): *Monadic Concurrent Linear Logic Programming*. In: A.Felty, editor: *Proceedings of the 7th International Symposium on Principles and Practice of Declarative Programming (PPDP'05)*, ACM Press, Lisbon, Portugal, pp. 35–46.
- [5] Frank Pfenning (2004): *Substructural Operational Semantics and Linear Destination-Passing Style*. In: W.-N. Chin, editor: *Proceedings of the 2nd Asian Symposium on Programming Languages and Systems (APLAS'04)*, Springer-Verlag LNCS 3302, Taipei, Taiwan, p. 196. Abstract of invited talk.
- [6] Frank Pfenning & Robert J. Simmons (2009): *Substructural Operational Semantics as Ordered Logic Programming*. In: *Proceedings of the 24th Annual Symposium on Logic in Computer Science (LICS 2009)*, IEEE Computer Society Press, Los Angeles, California, pp. 101–110.

- [7] Jeff Polakow (2001): *Ordered Linear Logic and Applications*. Ph.D. thesis, Department of Computer Science, Carnegie Mellon University.
- [8] Jeff Polakow & Kwangkeun Yi (2000): *Proving Syntactic Properties of Exceptions in an Ordered Logical Framework*. In: *Proceedings of the First Asian Workshop on Programming Languages and Systems (APLAS'00)*, pp. 23–32.
- [9] Jason C. Reed (2009): *A Hybrid Logical Framework*. Ph.D. thesis, Carnegie Mellon University. Available as Technical Report CMU-CS-09-155.
- [10] Anders Schack-Nielsen & Carsten Schürmann (2008): *Celf - A Logical Framework for Deductive and Concurrent Systems*. In: A. Armando, P. Baumgartner & G. Dowek, editors: *Proceedings of the 4th International Joint Conference on Automated Reasoning (IJCAR'08)*, Springer LNCS 5195, Sydney, Australia, pp. 320–326.
- [11] Robert J. Simmons & Frank Pfenning (2008): *Linear Logical Algorithms*. In: *Proceedings of the 35th International Colloquium on Automata, Languages and Programming (ICALP'08)*, Springer LNCS 5126, Reykjavik, Iceland, pp. 336–345.
- [12] Robert J. Simmons & Frank Pfenning (2009): *Linear Logical Approximations*. In: G. Puebla & G. Vidal, editors: *Proceedings of the Workshop on Partial Evaluation and Program Manipulation*, ACM SIGPLAN, Savannah, Georgia, pp. 9–20.
- [13] Kevin Watkins, Iliano Cervesato, Frank Pfenning & David Walker (2002): *A Concurrent Logical Framework I: Judgments and Properties*. Technical Report CMU-CS-02-101, Department of Computer Science, Carnegie Mellon University. Revised May 2003.
- [14] Kevin Watkins, Iliano Cervesato, Frank Pfenning & David Walker (2004): *A Concurrent Logical Framework: The Propositional Fragment*. In: S. Berardi, M. Coppo & F. Damiani, editors: *Types for Proofs and Programs*, Springer-Verlag LNCS 3085, pp. 355–377. Revised selected papers from the *Third International Workshop on Types for Proofs and Programs*, Torino, Italy, April 2003.
- [15] Kevin Watkins, Iliano Cervesato, Frank Pfenning & David Walker (2004): *Specifying Properties of Concurrent Computations in CLF*. In: C. Schürmann, editor: *Proceedings of the 4th International Workshop on Logical Frameworks and Meta-Languages (LFM'04)*, Electronic Notes in Theoretical Computer Science (ENTCS), vol 199, pp. 133–145, 2008, Cork, Ireland.