A New Linear Logic for Deadlock-Free Session-Typed Processes (Talk Abstract)*

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Abstract

We propose a new type system for deadlock-free session-typed π-calculus, a core concurrent programming language, by integrating for the *first* time, two separate lines of work. The first is the *propositions-as-types* approach by Caires and Pfenning, which provides a linear logic foundation for session types and guarantees deadlock-freedom. The second is Kobayashi's approach in which types are annotated with *priorities* for detecting cyclic dependencies between communication operations. The outcome is a new and more expressive variant of classical linear logic with a proof assignment that gives a session type system with Kobayashi-style priorities.

CCS Concepts • **Software and its engineering → General programming languages**; *Formal Methods*; • **Theory of Computation →** *Concurrency*; *Logic*;

Keywords classical linear logic, session types, Curry-Howard

ACM Reference Format:
Ornela Dardha and Simon J. Gay. 2018. A New Linear Logic for Deadlock-Free Session-Typed Processes (Talk Abstract). In *Proceedings of Women in Logic Workshop (WiL2018).* ACM, New York, NY, USA, 1 page. https://doi.org/

Background and Contribution

The Curry-Howard correspondence, or *propositions-as-types* paradigm, provides a canonical logical foundation for *functional* programming. With the discovery of linear logic [4], it was natural to ask for a similar account of *concurrent* programming. There have been attempts to relate the π-calculus [6] to classical linear logic [1], without resulting in a convincing Curry-Howard correspondence for concurrency.

Meanwhile, Honda *et al.* [7] developed *session types* as a formalism to statically check communication protocols in the π-calculus. Caires and Pfenning [2] discovered a Curry-Howard correspondence between intuitionistic linear logic and π-calculus with session types [7]. Wadler [8] introduced CP, as an alternative formulation based on classical linear logic. The Caires-Pfenning approach gives a propositions-as-types theory of concurrent programming, and a logical foundation for session types. The type system guarantees deadlock-freedom by *forbidding* cyclic process structures.

However, rejecting cyclic process structures is strict: they are a *necessary*, but not *sufficient*, condition for the existence of deadlocked communication operations. Our contribution [3] is to define a new linear logic, *priority-based linear logic* (PLL), and formulate it as a session type system for *priority-based CP* (PCP), a more expressive class of session-typed π-calculus processes than Wadler's CP [8].

This is the *first Curry-Howard correspondence that allows cyclic interconnected processes, while still ensuring deadlock-freedom.* PLL is based on Kobayashi's type system [5] in which types are annotated with *priorities*. Priorities are natural numbers used to express conditions on inter-channel dependencies and detect deadlocks. On the technical results, we prove Cycle-elimination for PLL, analogous to the standard Cut-elimination for CLL. Cycle-elimination implies subject reduction, top-level deadlock-freedom, and full deadlock-freedom for closed processes for PCP. To conclude, our work can be viewed in three ways: (i) as a new linear logic in which cyclic proof structures can be derived; (ii) as an extension of Caires-Pfenning type systems so that they accept more processes, while maintaining the strong logical foundation; (iii) as a logical foundation for Kobayashi-style type systems.

*Supported by the UK EPSRC grant EP/K034413/1, "From Data Types to Session Types: A Basis for Concurrency and Distribution (ABCD)", and by COST Action IC1201, "Behavioural Types for Reliable Large-Scale Software Systems (BETTY)".

WiL2018, July 8, 2018, Oxford, United Kingdom
2018.

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