

## Coinductive equivalences for extended $\lambda$ -calculi

M2 internship, Daniel Hirschhoff, Plume team, ENS de Lyon

### Context

Coinductive proof techniques have been developed to reason about various kinds of foundational calculi, notably concurrent process calculi such as CCS and the pi-calculus, the lambda-calculus and some of its extensions.

In such a setting, the (coinductive) bisimulation proof method can be enhanced with various techniques, which make the development of proofs of equivalences between programs easier.

### The internship

The goal of this internship is to study coinductive proof techniques for non-deterministic extensions of the lambda-calculus. The student is expected to get familiar with relevant works in the field (see the bibliography below), and to work on the analysis of behavioural equivalences for extended lambda-calculi (we will consider, in particular, various strategies, as well as extensions of lambda-calculi with imperative aspects). The goal is to propose new behavioural equivalences, with appropriate proof techniques, in order to reason about functional programs with non-deterministic behaviours.

This internship will take place in the Plume team of the LIP laboratory (ENS de Lyon). It will be jointly supervised by Daniel Hirschhoff (Plume) and Davide Sangiorgi (Universit di Bologna and INRIA). Visits can be organised to discuss on the progress of the internship.

**Bibliography** (*see the links below for complete references to the works*)

1. Davide Sangiorgi, Naoki Kobayashi, Eijiro Sumii, Environmental Bisimulations for Higher-Order Languages
2. S. Lassen, Relational Reasoning about Functions and Nondeterminism
3. D. Sangiorgi, Introduction to Bisimulation and Coinduction